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VOLUME 19 JANUARY, 1945 NUMBER 1

NORTH AMERICAN CYMATOCERATIDAE (MESOZOIC NAUTILOIDEA)

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ABSTRACT—The seven generic representatives of the Cymatoceratidae are compared and contrasted. All the North American species that belong in this family are referable to *Cymatoceras* and *Paracymatoceras*, and each of them is discussed at some length.

UNTIL the latter part of the past century, most of the Mesozoic nautiloids were generally referred to the genus *Nautilus*, of which the type species is *N. pompilius*, now living in the South Pacific. Various authors then segregated small groups and proposed generic names for them. Thus, in 1884, Hyatt established *Cymatoceras* for "Cretaceous species . . . remarkable for their transverse costae"; and he designated as genotype *Nautilus pseudo-elegans* d'Orbigny of the Lower Cretaceous (Neocomian) of Europe and possibly Asia.

Subsequent authors have referred to *Cymatoceras* several species from the Lower Cretaceous of America. This action seems to have resulted from the fact that the surface ornamentation of the test of these American forms bears at least a superficial resemblance to that of the Eurasian genotype.

In 1910, Spengler published an excellent study of the Cretaceous nautiloids of southern India. He regarded *Cymatoceras* as a subgenus of *Nautilus* but was able to recognize several fairly distinct groups of species. Somewhat later (1927), Spath reviewed briefly all the post-Triassic nautiloid genera and established a number of new ones. He more or less expanded Hyatt's genus *Cymatoceras* into a family, Cymatoceratidae, in which he placed besides *Cymatoceras*, his then new genera: *Procymatoceras*, *Cymatonautilus*, *Paracymatoceras*, *Syrionautilus*, *Anglonautilus*, and *Eucymatoceras*.

Unfortunately, Spath failed to diagnose his new genera, and he did not indicate the generic affinities of the American forms that had been placed in *Cymatoceras*. Accordingly, it now remains for the distinguishing characters of each of these seven genera to be pointed out and the proper taxonomic position of the American forms to be determined.

For the most part, the data presented in this study came from Eurasiatic and American literature and American specimens. For the loan of the latter, we are indebted to Alfred R. Loeblich of Tulane University and James P. Conlin of Fort Worth, Texas. Acknowledgement is also due to Lee Allen, who retouched the photographs that accompany this report, and to the Graduate College of the State University of Iowa for financial assistance.

Family CYMATOCERATIDAE Spath, 1927

All seven of the genera that constitute this family have nautiliconic conchs which, at maturity, bear sinuous transverse ribs or

plications. In some the umbilicus is closed, but in others it is open and rather large. The sutures also vary considerably, being only slightly sinuous in certain genera and forming prominent lobes and saddles in others. Comparatively little information is available in regard to the siphuncle, but it is almost certainly orthochoanitic in structure in all representatives of the family and in general it tends to be more or less subcentral in position—at least, it is not marginal.

In discussing this family, Spath has pointed out several things that are particularly noteworthy. For example, the ribbing in *Syrionautilus* is reminiscent of the Triassic Clydonautilidae, and in that genus, in *Anglonautilus*, and in *Eucymatoceras* is sufficiently distinct for generic separation of their respective groups. Tagliarini's group of "*Nautilus toarcensis* d'Orbigny," with *N. marii* Gemmellaro, may possibly lead up to the somewhat similar *Procymatoceras subtruncatum* (Morris and Lycett) and *P. baberi* (Morris and Lycett) with their costate *Bellerophon*-like outer whorls. Also, *Procymatoceras* may have descended from *Nautilus polygonalis* Sowerby of the Inferior Oolite (lower Middle Jurassic) of Great Britain, which has been considered by Brauns to be possibly identical with *P. subtruncatum* of the same general horizon and locality.

Geographically this family is indeed widespread, and it can be said to have a world-wide distribution. Stratigraphically it appears to be confined to the Jurassic and the Cretaceous, but it ranges throughout most of those two systems.

FIG. 1—The genoholotype of *Cymatoceras*, *C. pseudo-elegans* (d'Orbigny) from the Lower Cretaceous (Neocomian) of France, ×½. After Foord.

Genus CYMATOCERAS Hyatt, 1884

Genotype, *Nautilus pseudo-elegans* d'Orbigny.

This genus, in its present restricted sense, includes only those forms very close to its genotype, *Nautilus pseudo-elegans* d'Orbigny of the Lower Cretaceous (Neocomian) of France, England, and possibly India and Crimea (text fig. 1). In that species the nautiliconic conch is large, and the whorls are broadly rounded and are considerably

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EXPLANATION OF PLATE 1

FIGS. 1, 2—*Cymatoceras hilli* (Shattuck). Two views of a well-preserved internal mold (U. S. Nat. Mus. 103,678, ×1) from the Main Street formation (upper Washita) along Deer Creek on the east side of the Burleson-Crowley road, some 15 miles south of Fort Worth, Texas. ×1. (p. 5)

2

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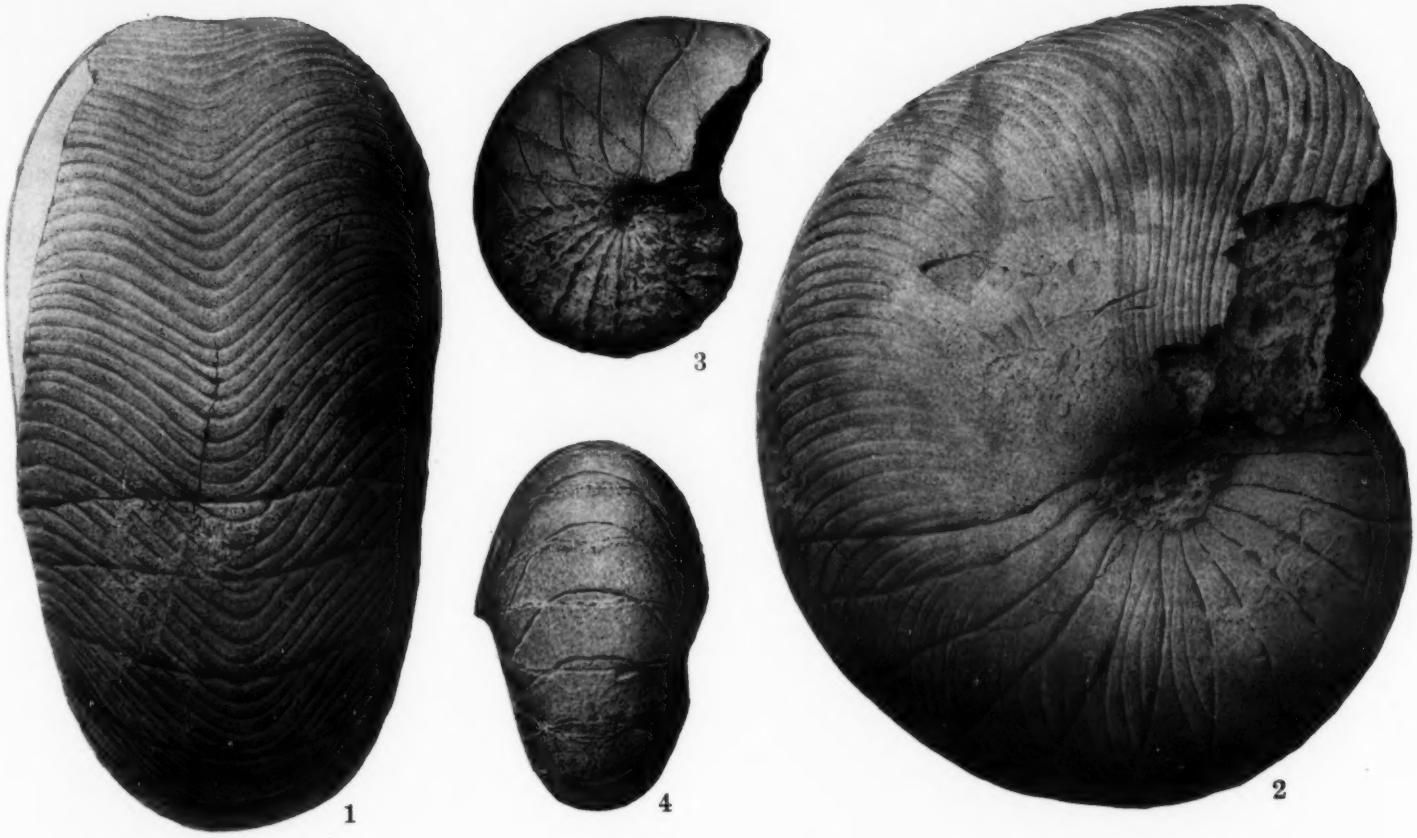
Miller and Harris, Mesozoic Nautiloidea



Miller and Harris, Mesozoic Nautiloidea

wider than high. The closed umbilicus is small but rather distinct. The surface of the test is transversely lirate during early adolescence, and at maturity it bears prominent rounded ridges or plications, subdued replicas of which are present on the internal mold. These ribs form slightly sigmoidal curves on the lateral zones of the conch and broad, moderately deep, rounded ventral sinuses. The sutures form broad, shallow, rounded lateral lobes and similar ventral saddles. The siphuncle, which is almost certainly orthochoanitic in structure, is "situated below the centre of the septa."

As noted by Spath, the

> typical ornamentation of *Cymatoceras*, of course, may be only feebly developed, as in *C. bouchardianum* (d'Orbigny, 1842, pl. xii) or in *C. ovoideum* (Crick, 1907, p. 222).

The very small, immature specimen from the Cretaceous (Cenomanian) of Kent, England, which Crick figured in 1918 (pl. 9, fig. B) and which Spath (1927, p. 34) referred to *Cymatoceras*, has longitudinal as well as transverse ribs on the surface of its test—presumably this reticulate character was lost before maturity was attained, as is that of *C. gabbi* (Anderson). *C. undulatiformis* Spath [= *Nautilus plicatus* Zwierzycki, not Fitton] of the Lower Cretaceous of southeastern Africa belongs in this genus rather than in *Anglonautilus*, which it superficially resembles.

Typical *Cymatoceras* resembles *Paracymatoceras*, but its sutures are less strongly sinuous. It seems probable that these two genera will prove to be more or less gradational as are, for example, *Cimonia* and *Hercoglossa* of the early Tertiary. *Cymatoceras* also resembles *Syrionautilus*, from which it differs in that its transverse ribs are more strongly sinuous and are rounded rather than acute.

Insofar as can be told from the available literature, this genus is confined to the Cretaceous. However, it is widespread in that system in Europe, Asia, Africa, and North America, and it is well represented in both the Lower and the Upper Cretaceous.

CYMATOCERAS? AVERILLI (Anderson)

Nautilus averilli ANDERSON, 1938, Geol. Soc. America Spec. Papers 16, p. 139, pl. 10, fig. 2.

It is not possible to ascertain the generic affinities of this species from the published illustration and description. However, in general physiognomy its conch seems to resemble *Cymatoceras*, its sutures are stated to be "simple" but to be slightly sinuous, and a fragment of the test adhering to the holotype shows

> faint growth lines rising vertically on the lower [dorsal] half of the whorl but curving sharply backward on the upper [ventral] part of the side, and forming a sharply rounded sinus in the ventral zone.

Occurrence.—Barr zone, near the middle of the Horsetown group, about 5 miles south of Ono, Shasta County, California.

CYMATOCERAS? CAMPBELLI (Meek)

Nautilus campbelli MEEK, 1861, Philadelphia Acad. Nat. Sci. Proc., vol. 13, p. 318; 1876, U. S. Geol. and Geog. Survey Terr. Bull., vol. 2, no. 4, p. 373, pl. 6, figs. 2, 2a. WHITEAVES, 1879, Canada Geol. Survey Mesozoic fossils, vol. 1, pt. 2, p. 99, pl. 11, figs. 2–2b; 1903, Canada Geol. Survey Mesozoic fossils, vol. 1, pt. 5, p. 327.

?*Nautilus dekayi* SHUMARD, 1858, St. Louis Acad. Sci. Trans., vol. 1, p. 124. WHITEAVES, 1879, Canada Geol. Survey Mesozoic fossils, vol. 1, pt. 2, pp. 99–100; 1903, Canada Geol. Survey Mesozoic fossils, vol. 1, pt. 5, p. 327.

The conch of this species is "subglobose" as the whorls are distinctly wider than high, are considerably impressed dorsally, and are broadly and rather evenly rounded laterally and ventrally. The umbilicus is small, and the camerae are moderate in length. The sutures of the holotype, a completely septate internal mold almost 125

EXPLANATION OF PLATE 2

FIGS. *1–4*—*Cymatoceras loeblichi* Miller and Harris, n. sp. The holotype (figs. 1, 2) and the smaller paratype (figs. 3, 4). both from the Washita group of north-central Texas. *1, 2*, The holotype (U. S. Nat. Mus. 103,681, ×0.8), from the Weno formation at the contact with the overlying Pawpaw clay on the east side of the Fort Worth-Mansfield road about 0.2 mile southeast of Sycamore Creek, Tarrant County, Texas. *4, 5*, The paratype (U. S. Nat. Mus. 103,682, ×1), from the Grayson formation west of the Pottsboro-Fink road about 2.5 miles north of Pottsboro, Grayson County, Texas. (p. 6)

mm. in diameter, are somewhat sinuous, and Meek states that they arch "slightly backward on the sides and periphery." No trace of the siphuncle or the surface markings of the test is preserved on the holotype, but small plesiotypes studied by Whiteaves show that the siphuncle is located fairly close to the dorsum and that the surface of the test is

> marked by shallowly concave revolving grooves, and these are crossed by rather distant, transverse, crenate ridges, the intervals between which are almost filled by close-set, numerous crenate striae which run parallel both to each other and to the ridges.

The published illustrations of this form indicate that it resembles typical *Cymatoceras* in size and shape of conch and umbilicus. However, its sutures and the surface markings of its test need to be restudied before its affinities with that genus can be regarded as certain.

Occurrence.—The holotype came from the Cretaceous of Comox, Vancouver Island. According to Whiteaves conspecific specimens have been found in the Cretaceous of nearby islands (Hornby Island and the Sucia Islands) and possibly along the Nanaimo River of Vancouver Island.

CYMATOCERAS CARLOTTENSE (Whiteaves)

Nautilus sp. WHITEAVES [part], 1876, Canada Geol. Survey Mesozoic fossils, vol. 1, pt. 1, pp. 14–18.

Nautilus suciensis WHITEAVES, 1884, Canada Geol. Survey Mesozoic fossils, vol. 1, pt. 3, pp. 197–198, pl. 21, fig. 1. [Not *N. suciensis* Whiteaves, 1879.]

Nautilus (*Cymatoceras*) *carlottensis* WHITEAVES, 1900, Canada Geol. Survey Mesozoic fossils, vol. 1, pt. 4, pp. 269, 305.

?*Nautilus charlottensis* ANDERSON, 1902, California Acad. Sci. Proc., ser. 3, Geology, vol. 2, no. 1, p. 78; 1938, Geol. Soc. America Spec. Papers 16, p. 138.

In 1900 Whiteaves recognized that the cymatoceratids from the Queen Charlotte Islands are not conspecific with those known from the largest of the Sucia Islands near Vancouver (with which he had formerly placed them), and he accordingly proposed a new specific name for the former. Insofar as can be told from the published illustration and description, this species is a typical representative of the genus *Cymatoceras*, resembling in general physiognomy *C. loeblichi*. It attains a large size, its whorls are about as wide as high, its umbilicus is closed or nearly so, the surface of its test bears prominent strongly sinuous ribs, its sutures are slightly sinuous, and its siphuncle is subcentral. The largest specimens known are said to be about 7 inches in diameter and there is a "faint longitudinal depression or shallow groove in the middle of the venter."

Occurrence.—The specimen that should probably be regarded as the holotype of this species is stated to be from Maple Island in Skidegate Inlet, British Columbia, and it is Upper Cretaceous in age. Specimens that presumably are conspecific have been collected at one or two other localities near Skidegate Inlet, almost certainly from beds of the same general age. We have not seen the specimens from the Horsetown group and from a boulder in the Chico series of Shasta County, California, which Anderson referred to this species, but did not illustrate or describe. Hence we can not confirm or reject the identification. It should, however, be noted that Anderson states that in

> the Horsetown examples the siphonal tube is perhaps a little lower in its position that in the northern specimens and that the conch is somewhat larger and possibly a little more inflated.

CYMATOCERAS GABBI (Anderson)

Nautilus texanus? GABB, 1864, California Geol. Survey Palaeontology, vol. 1, pp. 59, 220, pl. 9, figs. 3a, 3b. WHITEAVES, 1876, Canada Geol. Survey Mesozoic fossils, vol. 1, pt. 1, p. 19. HEILPRIN, 1882, Philadelphia Acad. Nat. Sci. Proc., vol. 34, p. 200. STANTON, 1896, U. S. Geol. Survey Ann. Rept. 17, pt. 1, p. 1030. MILLER and THOMPSON [part], 1933, Jour. Paleontology, vol. 7, p. 307.

Nautilus elegans GABB, 1877, Philadelphia Acad. Nat. Sci. Proc., vol. 28, p. 278.

Nautilus gabbi ANDERSON, 1905, California Acad. Sci. Proc., ser. 3, Geology, vol. 2, pp. 77–78; 1938, Geol. Soc. America Spec. Papers 16, p. 138, pl. 10, fig. 1.

Although the sutures of this form appear to be somewhat more strongly sinuous than those of other species being referred to *Cymatoceras*, at least the figured syntype (Gabb, 1864, pl. 9, figs. 3a, 3b) seems to be referable to that genus. It is only superficially similar to *Paracymatoceras texanum* (Shumard), to which it was referred with question by early authors. Its whorls are

considerably wider than high and are broadly rounded laterally and ventrally; and they bear the sinuous transverse ribs that are so characteristic of the cymatoceratids. Small specimens show in addition to these ribs,

fine revolving striae that give a beautiful cross-hatched sculpture that is not seen in any of the older specimens.

The umbilicus is small and inconspicuous, and the siphuncle is small and is located closer to the dorsum than the venter.

?*Nautilus*, n. sp. HILL, 1889, Texas Geol. Survey Bull. 4, p. 21. ADKINS, 1928, Texas Univ. Bull. 2838, p. 200.

Nautilus hilli SHATTUCK, 1903, U. S. Geol. Survey Bull. 205, p. 35, pl. 23, fig. 3; pl. 24, figs. 3, 4.

Nautilus texanus ADKINS and WINTON [part], 1920, Texas Univ. Bull. 1945, p. 32, pl. 20, figs. 1, 2. SCOTT [part], 1926, Univ. Grenoble, Thèse, p. 68.

Cymatoceras hilli ADKINS, 1928, Texas Univ. Bull. 2838, pp. 199–200.

?*Cymatoceras simplex* ADKINS [part], 1928, Texas Univ. Bull. 2838, p. 200.

In the original description of this species it is stated that the test is "without decora-

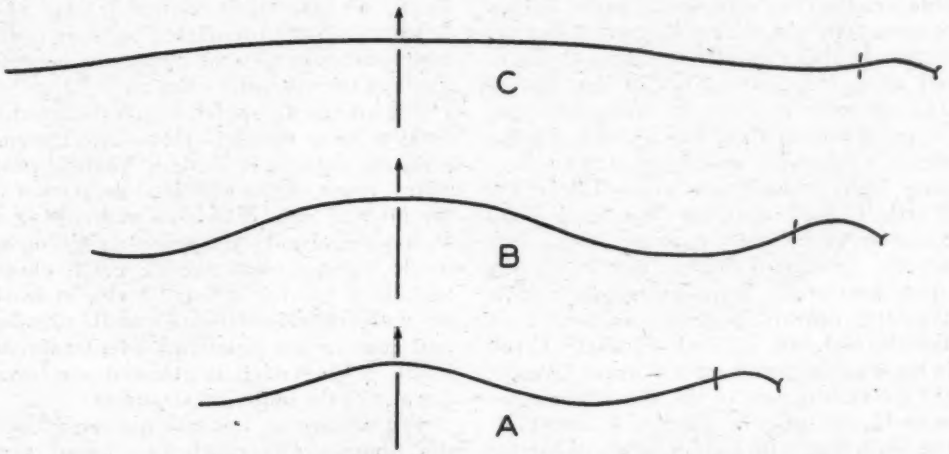


FIG. 2—Sutures of **(A, B)** *Cymatoceras hilli* (Shattuck) and **(C)** *C. loeblichi* Miller and Harris, n. sp., all ×1. **A** is based on the specimen represented by fig. 4, pl. 4, where the conch is about 40 mm. high; **B** on figs. 1, 2, pl. 1, where the conch is about 55 mm. high; and **C** on figs. 1, 2, pl. 2, where the conch is about 60 mm. high.

Occurrence.—This species is found in the upper part of the Horsetown formation (Lower Cretaceous) of Anderson's Gulch and Cottonwood Creek, Shasta County, California; and it is stated to occur also about 8 miles southeast of Lompoc, Santa Barbara County, California. Related forms, that may possibly be identical, have been recorded from the Cretaceous of California near Mount Diablo (and possibly elsewhere) in Contra Costa County and in the Santa Ana Mountains of Orange County.

CYMATOCERAS HILLI (Shattuck)

Plate 1, figures 1, 2; plate 4, figures 4, 5; plate 5, figure 4.

?*Nautilus simplex* ROEMER, 1852, Die Kreidebildungen von Texas und ihre organischen Einschlüsse, p. 37.

tions and is smooth except for minute growth lines just distinguishable." However the published illustrations of the two figured syntypes indicate that their preservation leaves much to be desired, and it seems quite possible that their tests may well have borne transverse ribs that failed to leave traces on the internal mold. The specimen represented by figure 4 on plate 4 of the present publication reveals no markings other than the sutures. Also, figure 2 on plate 1 shows distinct traces of ribs on only three small areas, but such traces are quite distinct on most of the opposite side of this specimen (pl. 2, fig. 1).

A direct comparison of the two specimens just discussed leaves little doubt but that they are conspecific, and both seem to be very close to the figured syntypes of

"Nautilus" hilli. Furthermore, the largest of the specimens figured in this report is clearly referable to *Cymatoceras* as it bears the characteristic transverse ribs and its sutures are not as strongly sinuous as are those of *Paracymatoceras.* One of the large specimens that we are referring to this species shows that at full maturity the phragmacone attains a diameter of as much as 165 mm. The siphuncle, which is small in size, is composed of cylindrical segments and is therefore orthochoanitic in structure.

Occurrence.—Insofar as we have been able to ascertain, this species is not known to occur outside of the Washita of central Texas; stratigraphically it ranges throughout all but the extremities of that group. The syntypes are from the Buda limestone (upper Washita) along Shoal Creek, Austin, Texas. Conspecific specimens in the collections being studied are from (1) the Ft. Worth formation (lower Washita) along Sycamore Creek in Sycamore Park, Fort Worth, Tarrant County, Texas; (2) the upper part of the Weno formation (middle Washita) near Katy Lake, south of Fort Worth; and east of Rock (Turkey) Creek in the southwestern part of Tarrant County; (3) the middle part of the Weno formation near Haslet, also in Tarrant County; (4) the Main Street formation (upper Washita) along Deer Creek on the east side of the Burleson-Crowley road, some 15 miles south of Fort Worth; and about 3½ miles northeast of Roanoke, Denton County, Texas; and (5) the so-called "transition zone of Adkins" between the Main Street and the Grayson formations (upper Washita) of north-central Texas.

CYMATOCERAS LOEBLICHLI Miller and Harris, n. sp.

Plate 2, figures 1–4; plate 3, figures 3, 4.

This species is based on three specimens, the largest of which is designated as the holotype (pl. 2, figs. 1, 2). This specimen attains a maximum diameter of about 150 mm.; and near its adoral end the conch is about 80 mm. high and is approximately as wide as high. As shown by figures 3 and 4 on plate 2, during early maturity the conch is slightly wider than high. The holotype is not complete adorally, but the portion of it that represents living chamber is almost two-fifths of a volution in length. The living chamber of the larger paratype (pl. 3, figs. 3, 4) appears to be essentially complete, and it is also about two-fifths of a volution in length. In this latter specimen there is a broad, shallow, rounded groove immediately posterior to what appear to be remnants of the apertural margins.

The umbilicus is small but on the internal mold is very distinct. However, it seems probable that, as in modern *Nautilus pompilius,* much of the umbilical depression of the internal mold was filled with a plug of shell material and that testiferous specimens would show a small inconspicuous closed umbilicus. On the internal mold, at least, the umbilical shoulders are broadly rounded and more or less indefinite. The maximum width of the conch is attained somewhat ventrad of the umbilical shoulders.

The surface of the internal mold bears low, rounded ribs which form broad, very shallow lateral sinuses and prominent deep, very narrowly rounded, almost V-shaped ventral sinuses. The details of the surface ornamentation are none too well preserved on the type specimens, but the sinuous transverse ribs do not seem to be increased in number by bifurcation or implantation.

The camerae are moderate in length. The sutures are only slightly sinuous, and at full maturity each external suture (text fig. 2C) forms a low, broad, flattened ventral saddle, a broad, shallow, rounded lateral lobe, and a small relatively prominent saddle in the region of the umbilicus. Traces

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EXPLANATION OF PLATE 3

FIGS. *1, 2—Paracymatoceras texanum* (Shumard). A phragmacone (James P. Conlin coll., ×1) preserved in chert, from the midportion of the Weno formation near Haslet, Tarrant County, Texas. (p. 10)

3, 4—Cymatoceras loeblichi Miller and Harris, n. sp. Two views of the larger paratype (James P. Conlin coll. ×¾), from the zone of *"Mortoniceras maxima"* in the Fort Worth formation (about 9 ft. below the Fort Worth-Denton contact) near Rock Creek about 4 miles south of Blum, Hill County, Texas. (p. 6)

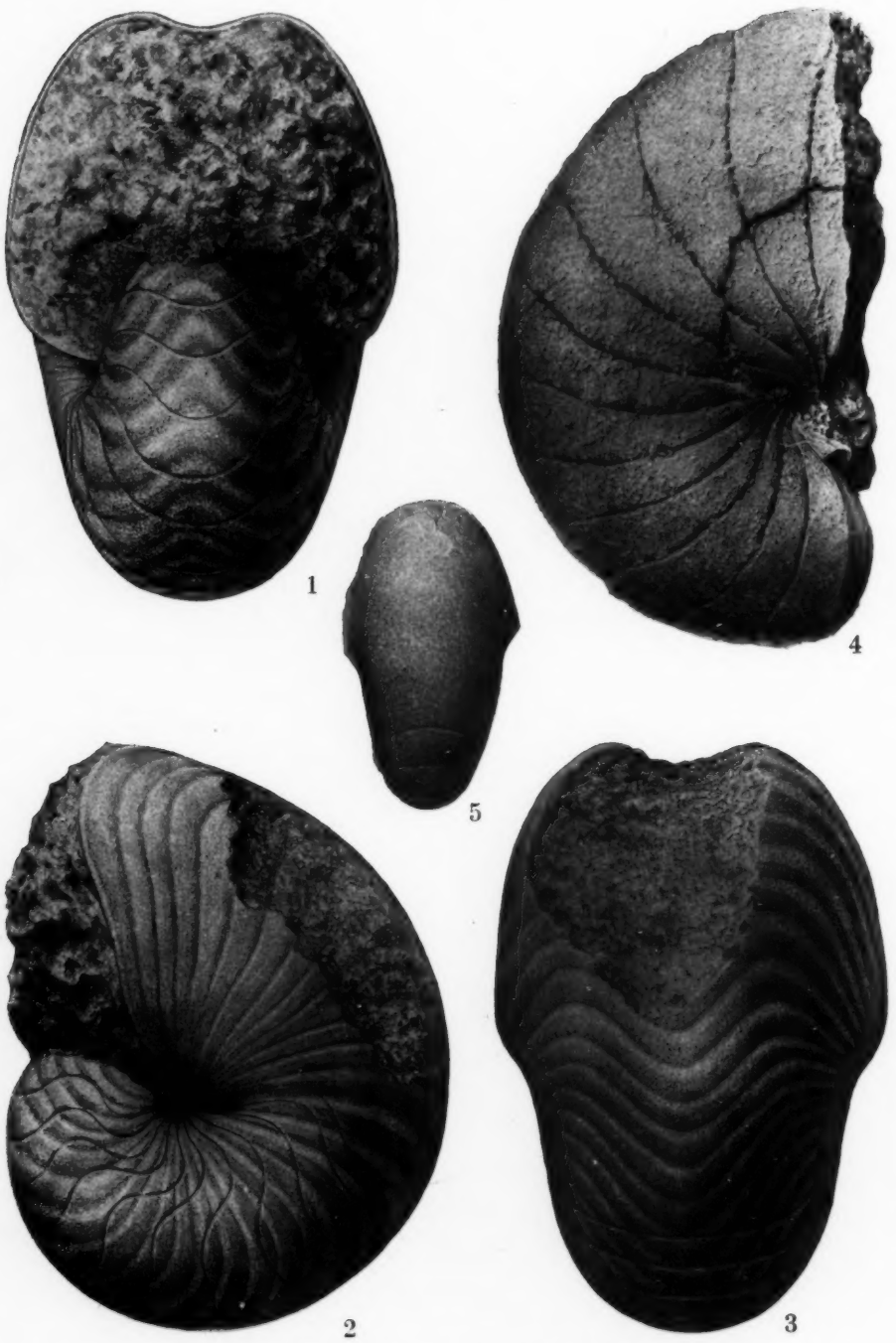
1

2

3

4

Miller and Harris, Mesozoic Nautiloidea



Miller and Harris, Mesozoic Nautiloidea

of the internal sutures can be seen adhering to the surface of the specimen represented by figures 3 and 4 on plate 2. These show that the internal sutures consist of a low, rounded saddle just inside the umbilical seam and a broad, shallow, rounded dorsal lobe, in the center of which there may be a small "annular lobe." No trace of the siphuncle is visible on any of the three type specimens.

Remarks.—Insofar as size, shape, and ornamentation of conch are concerned, this species resembles rather closely *Cymatoceras pseudoneokomiense* Shimizu of the Lower Cretaceous Hiraiga sandstone (lower Aptian) of Japan and *"Nautilus" neohispanicus* Burckhardt of the Lower Cretaceous (upper Aptian) of Mexico. However, the Japanese form bears coarser and more prominent ribs. The sutures of the Mexican form are, unfortunately, not known, and it may belong in either *Cymatoceras* or *Paracymatoceras;* since it is considerably older than *C. loeblichi* it probably is not conspecific, but so little detailed information is available in regard to it that specific comparisons are not possible.

Cymatoceras hilli (Shattuck) and *Paracymatoceras texanum* (Shumard), which occur in association with *C. loeblichi*, have more slender conchs and more strongly sinuous sutures. Also the ornamentation of *C. hilli* is relatively feeble.

Occurrence.—All three of the known representatives of this species came from the Washita group of north-central Texas. The holotype is from the Weno formation (at the contact with the overlying Pawpaw clay) on the east side of the Fort Worth-Mansfield road about 0.2 mile southeast of Sycamore Creek in Tarrant County, Texas. The larger paratype was found in the Fort Worth formation about 9 feet below the Fort Worth-Denton contact in the zone of *"Mortoniceras maxima"* along Rock Creek about 4 miles south of Blum, Hill County, Texas. The smaller paratype came from the Grayson formation west of the Pottsboro-Fink road about 2.5 miles north of Pottsboro, Grayson County, Texas.

Types.—U. S. National Museum, 103,681 (holotype) and 103,682 (smaller paratype); and private collection of James P. Conlin of Fort Worth, Texas (larger paratype).

CYMATOCERAS NEBRASCENSE (Meek and Hayden)

Nautilus elegans nebrascensis MEEK and HAYDEN, 1862, Philadelphia Acad. Nat. Sci. Proc., vol. 14, p. 25. MEEK, 1864, Smithsonian Misc. Coll., vol. 7, no. 177, p. 25. WHITEAVES, 1876, Canada Geol. Survey Mesozoic fossils, vol. 1, pt. 1, p. 18. FOORD, 1890, Geol. Mag., n. ser., dec. 3, vol. 7, pp. 544–545.

Nautilus elegans MEEK, 1876, U. S. Geol. Survey Terr. (Hayden), vol. 9, pp. 499–501, pl. 8, figs. 2a–2c. STANTON, 1893, U. S. Geol. Survey Bull. 106, pp. 163–164, pl. 35, fig. 1.

When Meek and Hayden described this form they regarded it as a distinct variety of *"Nautilus" elegans* Sowerby of the Cretaceous of Great Britain and Europe. Later, however, after considering the matter thoroughly, Meek concluded that the American specimen agrees

> so closely with Sowerby's species that there may be no necessity for separating it even as a variety.

About the same time, Whiteaves expressed the opinion that

> the varietal name, proposed by Mr. Meek [and Mr. Hayden], may have to be raised to specific rank, as the sculpture of the so-called "variety *Nebrascensis*" is said to consist of ribs which are "five times as broad as the grooves between," and in this respect it differs from . . . nearly related, species.

It now seems clear that Whiteaves was correct and that Meek and Hayden's name

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EXPLANATION OF PLATE 4

FIGS. *1–3—Paracymatoceras asper* (Oppel). Three views of the type specimen (the genoholotype of *Paracymatoceras*), from the Stramberger beds (Upper Jurassic) of Stramberg, Moravia, ×1. (After Zittel.) (p. 9)

4, 5—Cymatoceras hilli (Shattuck). *4*, Lateral view of a moderate-sized specimen (U. S. Nat. Mus. 103,680, ×1), from the lower Main Street formation (upper Washita) about 1¼ miles east of the Fort Worth-Denton highway and some 3½ miles northeast of Roanoke, Denton County, Texas. *5*, Ventral view of a small specimen (U. S. Nat. Mus. 103,679, ×1) from the Fort Worth formation along Sycamore Creek in Sycamore Park, Fort Worth, Tarrant County, Texas; same specimen as pl. 5, fig. *4*. (p. 5)

will have to be revived for the Montana form, which should be regarded as a distinct species. Meek's illustrations and description indicate clearly that it belongs in *Cymatoceras* and that its whorls are much lower, wider, and more broadly rounded than any of the other known American representatives of the genus. According to Meek, where the holotype is about 3.9 inches in diameter its conch is about 3.4 inches wide. The surface of the test bears rather prominent growth lines parallel to the transverse ribs, the sutures are only slightly sinuous, and the siphuncle is located somewhat closer to the venter than the dorsum.

Occurrence.—The only known representative of this species came from the Upper Cretaceous Benton shale at Chippewa Point, Montana.

CYMATOCERAS? NEOHISPANICUM (Burckhardt)

Nautilus neohispanicus BURCKHARDT, 1925, Inst. geol. México Bol. 45, pp. 7–8, pl. 1, figs. 1–4. ADKINS, 1932, Texas Univ. Bull. 3232, p. 295. ?*Nautilus* aff. *N. texanus* ADKINS, 1933, Texas Univ. Bull. 3232, p. 305.

This species is not represented in the collections under consideration, and no information is available in regard to its sutures or its siphuncle. In general physiognomy it appears to resemble *Cymatoceras loeblichi*, and accordingly it is being doubtfully referred to the same genus—it may of course belong in *Paracymatoceras*.

Burckhardt discussed in considerable detail the nature of the sinuous transverse ribs in this form. In most representatives of this group, the development of these ribs is not very regular, and therefore it is doubtful if the details are as significant as Burckhardt seems to have believed.

Occurrence.—The holotype of this species came from the zone of *Douvilleiceras* in the upper Aptian (about middle Trinity) of Durango, north-central Mexico. Presumably conspecific specimens occur in the middle Trinity (Cuchillo formation and possibly the Glen Rose limestone) of west Texas.

CYMATOCERAS SUCIENSE (Whiteaves)

Nautilus sp. WHITEAVES [part], 1876, Canada Geol. Survey Mesozoic fossils, vol. 1, pt. 1, p. 17.

Nautilus suciensis WHITEAVES, 1879, Canada Geol. Survey Mesozoic fossils, vol. 1, pt. 2, pp. 97–99, pl. 11, figs. 1, 1a; 1903, Canada Geol. Survey Mesozoic fossils, vol. 1, pt. 5, pp. 327, 407. [Not *N. suciensis* Whiteaves, 1884.]

The figured type specimen of this species is a moderately large nautilicone in which the volutions are slightly wider than high, the umbilicus is closed and not very conspicuous, the surface of the test bears narrowly rounded sinuous ribs with broad, rounded intermediate grooves, the sutures are slightly sinuous, and the siphuncle is subcentral. Perhaps the most distinctive feature of this species is the ribbing, which is more or less intermediate between that of typical *Cymatoceras* and typical *Anglonautilus*. However, in the latter genus both the internal mold and the exterior of the test are affected by the ribs or plications, and the ribbing is not as prominent on the lateral as on the ventral zones of the conch. In *C. suciense*, on the contrary, the internal mold appears to be smooth and the ribs are more prominent laterally than ventrally.

Occurrence.—The figured type specimen of this species came from the Nanaimo group (Upper Cretaceous) in the southwestern part of the largest of the islands in the Sucia Island group, near Vancouver, British Columbia. Insofar as can be told from the literature, all of the other known representatives of the species came from the same horizon and locality.

Genus ANGLONAUTILUS Spath, 1927

Genotype, *Nautilus undulatus* Sowerby.

Sowerby's illustrations and brief description of the type species of this genus indicate that it includes large gibbous nautilicones in which the volutions are somewhat higher than wide. The surface of the internal mold, and presumably also the test, bears large rounded transverse undulations which are sinuous, forming lateral salients and ventral sinuses—in the outer volution of Sowerby's illustrated type specimen, a phragmacone, there appear to be about 20 of these sinuous undulations. The sutures are oblique to the undulations, and they form broad, shallow, rounded lateral lobes and similar ventral saddles. The siphuncle is moderately small and is subcentral in position, being located slightly nearer the dorsum than the venter.

The most distinctive feature of this genus is probably the large rounded surface undulations. Sowerby indicates that in large specimens these undulations become relatively far apart.

The species for which this genus was established has been found at several localities in the Cretaceous of England. Similar forms, which may be conspecific, are known from Cretaceous strata in France, Switzerland, and possibly Germany.

Genus CYMATONAUTILUS Spath, 1927

Genotype, *Nautilus julii* Baugier.

The type species of this genus was named by Baugier in a manuscript that apparently was never published. With a brief description in his *Prodome de paléontologie stratigraphique*, d'Orbigny (1850, p. 328) established the species, which he ascribed to Baugier. Then, in 1865, Guéranger illustrated it and described it much more fully.

Insofar as can be told from these illustrations and descriptions, this genotype is of moderate size. Its volutions, which are slightly wider than high, are flattened and grooved laterally and ventrally and narrowly rounded ventrolaterally. The umbilicus is rather large—its diameter is equal to about one-third that of the specimen. The surface of the internal mold, and presumably also that of the test, bears sinuous transverse ridges, of which there are some 40 to the volution. These ridges form rather prominent, broadly rounded lateral salients and deep, narrowly rounded ventral sinuses. The sutures are not parallel to the ribs, and they form broad, rounded ventral lobes (which are shallower than the ventral sinuses of the ribs), rather narrowly rounded ventrolateral saddles, broad, rounded lateral lobes, and narrower saddles on the umbilical shoulders. The siphuncle is small and subcentral but is closer to the dorsum than the venter.

This genus is readily differentiated from other members of the Cymatoceratidae by means of the ventral and lateral grooves in its conch. Also, unlike other members of this family, it has a large open umbilicus.

The only species that has been referred to this genus, the genotype, occurs in the basal Upper Jurassic (Callovian) of France.

Genus EUCYMATOCERAS Spath, 1927

Genotype, *Nautilus plicatus* Fitton.

The species that serves as the type of this genus has a large conch, which at full maturity has whorls that are more than twice as wide as high, and a closed umbilicus. The surface of the test is marked by small ribs, which form a large, deep, angular, V-shaped ventral sinus and on either side of it a similar but asymmetrical lateral salient. The sutures appear to be only slightly sinuous. The siphuncle is small and subcentral but is nearer the dorsum than the venter.

Clearly the most distinctive features of this genus are the low, broad volutions of the conch and particularly the zigzag markings of the test. The latter characteristic alone is sufficient to distinguish representatives from other contemporaneous forms.

The genotype was originally described from the Lower Cretaceous of England. Closely similar forms, at least part of which are conspecific, have been found in strata of the same general age on the Isle of Wight and in France, Switzerland, and Germany.

Genus PARACYMATOCERAS Spath, 1927

Genotype, *Nautilus asper* Oppel.

The specimen that has become the genoholotype of *Paracymatoceras* was illustrated and described by Zittel in 1868, and his illustrations are being reproduced herewith (pl. 4, figs. 1–3). Although there are certain obvious discrepancies in these illustrations, it seems clear that this form is of moderate size, and that its mature volutions are distinctly wider than high. The mature portions of the conch bear prominent transverse ribs, which are slightly sigmoidal on the lateral zones, and which form moderately deep, narrowly rounded ventral sinuses. The sutures are strongly sinuous, forming prominent rounded lateral lobes and ventral and dorsolateral saddles. The ventral saddles are considerably wider than the dorsolateral ones. Unfortunately, no information is available in regard to the siphuncle. However, in an American species, which is being regarded as congeneric, the siphuncle is small in size, subcentral in position, and almost certainly orthochoanitic in structure.

Both Zittel (1868, p. 48) and Spath

(1927, p. 25) believed that there was a rounded ventral groove in the adoral portion of the living chamber of the genoholotype, which appears to be a mature individual. However, comparable grooves (developed only in the adoral portions of mature individuals) are indeed rare, if they exist at all, in Mesozoic nautiloids, and therefore it seems likely that the groove in the genoholotype is adventitious. If not, it may serve to differentiate the European Jurassic from the American Lower Cretaceous forms, and it may possibly be of generic significance.

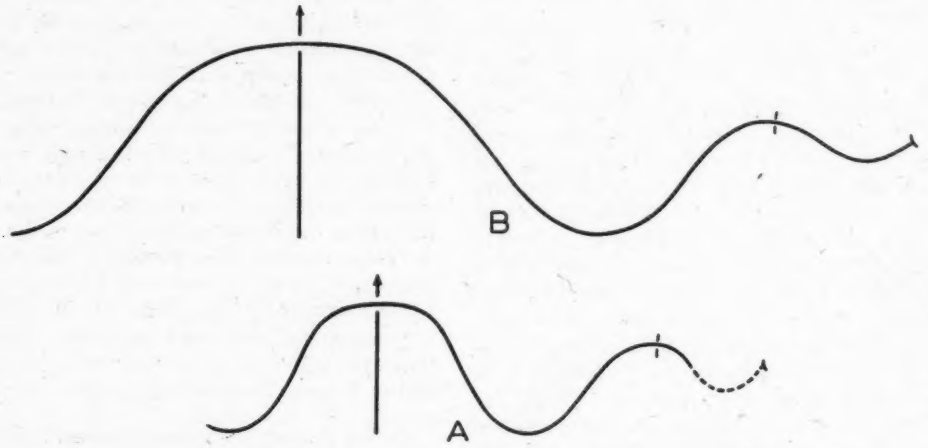

FIG. 3—Sutures of *Paracymatoceras texanum* (Shumard), both ×1. **A** is based on the specimen represented by fig. 2, pl. 5, where the conch is about 33 mm. high; **B** on fig. 1, pl. 5, where the conch is about 62 mm. high.

This genus is fairly close to typical *Cymatoceras*, but its sutures are more strongly sinuous and its conch is somewhat narrower. Presumably these two genera will be found to grade more or less into each other.

PARACYMATOCERAS TEXANUM (Shumard)

Plate 3, figures 1, 2; plate 5, figures 1–3.

?*Nautilus elegans* ROEMER, 1852, Die Kreidebildungen von Texas und ihre organischen Einschlüsse, p. 37. WHITEAVES, 1876, Canada Geol. Survey Mesozoic fossils, vol. 1, pt. 1, p. 18.

Nautilus texanus SHUMARD, 1860, St. Louis Acad. Sci. Trans., vol. 1, p. 590; 1861, Boston Soc. Nat. History Proc., vol. 8, p. 188. WHITEAVES, 1876, Canada Geol. Survey Mesozoic fossils, vol. 1, pt. 1, p. 18. HILL, 1889, Texas Geol. Survey Bull. 4, p. 21. CRAGIN, 1893, Texas Geol. Survey Ann. Rept. 4, p. 236. SHATTUCK, 1903, U. S. Geol. Survey Bull. 205, p. 34, pl. 23, figs. 1, 2; pl. 24, figs. 1, 2. WINTON and ADKINS, 1920, Texas Univ. Bull. 1931, pp. 58, 61, 66. ADKINS and WINTON [part], 1920, Texas Univ. Bull. 1945, p. 32. SCOTT [part], 1926, Univ. Grenoble, Thèse, p. 68. MILLER and THOMPSON [part], 1933, Jour. Paleontology, vol. 7, p. 307.

?*Cymatoceras elegans?* HYATT, 1894, Am. Philos. Soc. Proc., vol. 32, pp. 553–554, pl. 12, figs. 16–21. ADKINS, 1928, Texas Univ. Bull. 2838, p. 200.

?*Cymatoceras* (*Naut.*) (sp.?) HYATT, 1894, Am. Philos. Soc. Proc., vol. 32, pl. 12, figs. 16–21.

?*Nautilus washitanus* CRAGIN, 1894, Colorado Coll. Studies, 5th Ann. Publ., pp. 68–69.

Cymatoceras texanum ADKINS, 1928, Texas Univ. Bull. 2838, pp. 199–200.

This well-known species seems to resemble the genotype of *Paracymatoceras* rather closely, though its conch is more slender and its umbilicus is somewhat larger. Also, its ventral zone was convex throughout ontogenetic development, whereas that of *P. asper* may possibly have become concave at full maturity.

The general physiognomy and the surface markings of the conch are well illustrated by figures 1 and 2 on plate 3 and figures 1–3 on plate 5. Text figure 3 elucidates the shape of the rather strongly sinuous sutures during early and late maturity. The small siphuncle is located much closer to the dorsum than the venter. Some of the individuals in the collection under consid-

eration attain a diameter of more than 150 mm.

Occurrence.—The type specimens of this species came from the "Washita limestone, associated with *Epiaster elegans* and *Ostrea subovata*, near Austin and Bluffs of Red River, in Grayson County," Texas. According to Adkins (1928, p. 199) conspecific specimens are to be found throughout the "entire Washita division" of Texas; in Tarrant County, Texas, the species is well represented in the Fort Worth, Weno, and Main Street formations; and along Shoal Creek near Austin, Texas, it occurs in the Buda limestone. A few specimens that seem to be referable to this species have been found in the Duck Creek formation, but James P. Conlin has written us that in the Denton cymatoceratoids are rare or absent.

Genus PROCYMATOCERAS Spath, 1927

Genotype, *Nautilus subtruncatus* Morris and Lycett.

This genus has for its type species a moderately large subglobular nautilicone in which the conch is about twice as wide as high. The mature volutions are distinctly flattened laterally and ventrally and the lateral zones converge ventrad—the cross section is therefore more or less subtrapezoidal. The surface of the test bears prominent growth lines, which are somewhat fasciculate. They are slightly sigmoidal on the lateral zones of the conch and appear to form a moderately deep ventral sinus. The umbilicus is closed and is not very prominent. None of the specimens found at the type locality retains the septa or the siphuncle, but Foord (1891, p. 224) has referred to this species a specimen from another locality in England which "exhibits rather approximate, slightly flexuous septa." *Nautilus subtruncatus* Prinz (1906, pp. 228, 240) should be suppressed as a homonym of *N. subtruncatus* Morris and Lycett, which has priority.

Perhaps the most distinctive characteristics of *Procymatoceras* are the subtrapezoidal cross section of its conch and its prominent, somewhat fasciculate growth lines. It seems probable that the transverse surface markings of the test in this genus are not homologous with those of typical *Cymatoceras*.

The genotype occurs at more than one horizon in the Jurassic of England. A similar form, which Foord (1891, p. 224) thought to be conspecific, has been found in the Jurassic of northwestern France.

Genus SYRIONAUTILUS Spath, 1927

Genotype, *Nautilus libanoticus* Foord and Crick.

All the known representatives of the type species of this genus are more or less crushed and distorted, and unfortunately they do not reveal the nature of the septa, sutures, or the siphuncle. However, the nautiliconic conch appears to be moderately large, the rounded whorls are broad and are rapidly expanded orad, and the umbilicus is probably closed. The surface of the test (and to a lesser extent that of the internal mold) bears "prominent acute ribs, separated by interspaces rather exceeding their own width." These ribs seem to be directly transverse and to be almost straight. They are, to be sure, the distinguishing character of the genus and serve to differentiate it from such similar forms as *Cymatoceras* and *Paracymatoceras*.

The genotype, the only species that has been referred to the genus, is fairly abundant in the Upper Cretaceous (Senonian) of Syria.

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EXPLANATION OF PLATE 5

FIGS. *1–3*—*Paracymatoceras texanum* (Shumard). Three specimens from the Washita group of north-central Texas. *1*, U. S. Nat. Mus., 103,683, ×6/7, from the Fort Worth formation (lower Washita) on the west side of the Fort Worth-Primrose road about 4.1 miles southwest of Fort Worth, Tarrant County, Texas. *2*, U. S. Nat. Mus. 103,684, ×1.1, from the Weno formation (middle Washita) about 2 miles south of Fort Worth. *3*, James P. Conlin coll., ×1, from the Weno formation in Sycamore Creek under the bridge on the Evermann-Fort Worth road. (p. 10)

4—*Cymatoceras hilli* (Shattuck). Lateral view of a small specimen, U. S. Nat. Mus. 103,679, ×1, from the Fort Worth formation along Sycamore Creek in Sycamore Park, Fort Worth. Same specimen as pl. 4, fig. *5*. (p. 5)

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Miller, Permian Ammonoids

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MANUSCRIPT RECEIVED JULY 20, 1943.

EXPLANATION OF PLATE 6

FIGS. *1, 2*—*Pseudogastrioceras cooperi* Miller, n. sp. The holotype, ×1, from the upper part of the Leonard formation near the top of the slope on the northwest side of the road about one-half mile southwest of the old Word Ranch house in the Glass Mountains of Brewster County, Texas. (p. 13)

3–5—*Pseudogastrioceras roadense* (Böse). Two specimens from the third limestone of the Word formation on the northern slope of a hill on the southern side of Hess Canyon about 4 miles N. 35° E. of the Hess Ranch house in the Glass Mountains of Brewster County, Texas. *3, 4*, One specimen, ×7½; *5*, ×1. (p. 16)

6—*Agathiceras girtyi* Böse. A slightly crushed silicified specimen, ×2, from the second limestone of the Word formation on the main ridge extending into Hess Canyon north from Hill 5611 about one-half mile west of the 103° 10′ line in the Glass Mountains of Brewster County, Texas. (p. 16)

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SOME EXCEPTIONAL PERMIAN AMMONOIDS FROM WEST TEXAS

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ABSTRACT—Recent collecting in the Glass Mountains has yielded well-preserved representatives of *Medlicottia*, *Pseudogastrioceras*, *Adrianites?*, *Peritrochia*, *Stacheoceras*, and *Perrinites* from the Leonard formation; and *Medlicottia*, *Pseudogastrioceras*, *Agathiceras*, *Adrianites*, and *Waagenoceras* from the Word. The more significant features of these specimens are discussed and certain of them are illustrated. Also, there is included a study of a unique representative of *Waagenoceras* from the Capitan limestone of the Guadalupe Mountains.

RECENTLY G. A. Cooper of the U. S. National Museum sent me for study some exquisite Leonard and Word ammonoids which merit illustration and description. Also, Harold E. Vokes loaned me a few excellent specimens which he collected while with The American Museum of Natural History; and John W. Skinner of the Humble Oil and Refining Company sent me a unique specimen from the Leonard formation. I have drawn together into the form of a single study observations on all of this material. The photographs which accompany this report were retouched by Lee Allen, and acknowledgement is due to the Graduate College of the State University of Iowa for making the completion of this report financially possible.

Most of Cooper's specimens, on which the bulk of this report is based, are silicified, and they were obtained by dissolving the enclosing carbonate matrix in hydrochloric acid. By keeping the acid dilute, to avoid a violent reaction, and carrying on the dissolving process over a considerable period of time, Cooper was able to secure specimens that retain delicate processes and preserve the details of the surface markings of the test in remarkable perfection. In some cases all exposed surfaces were coated with celluloid before the fossiliferous limestone blocks were immersed in acid. As the etching progressed, the new surfaces exposed were coated to hold the parts of an individual together.

With the exception of a single specimen (*Waagenoceras guadalupense thompsoni* of the Guadalupe Mountains), all of the material under consideration came from the Leonard and Word formations of the Glass Mountains of Brewster County, Texas. The nature of these formations in this area is well known through the able work of P. B. King. The brachiopods they contain have been described by R. E. King, the fusulinids by Dunbar and Skinner, the pelecypods (of the Word only) by Newell, and the nautiloids by Miller; and Böse, Plummer and Scott, and Miller and Furnish have published extensively on the ammonoids. All of this work is of fairly recent date, and it is so readily available that it does not seem necessary or even desirable for me to attempt to summarize it here.

There is no doubt as to the age of the strata that yielded most of the specimens discussed in this report. However, near the top of the slope on the northwest side of the road about one-half mile southwest of the old Word Ranch house in the Glass Mountains, Cooper collected the following cephalopods:

Mooreoceras? sp.
Domatoceras? sp.
Medlicottia whitneyi Böse
Pseudogastrioceras cooperi, n. sp.
Adrianites? sp.
Stacheoceras sp.
Perrinites hilli (Smith)

He believes that the beds from which this assemblage came are the lower limestone member of the Word formation, but he states that in the field he "felt that there was quite an overlap between the base of the Word and the top of the Leonard." Most of

the cephalopods obtained at this horizon and locality are not very significant and could have come from either the Leonard or the Word. However, *Perrinites hilli*, which is abundant here, has for some years been regarded as characteristic of the Leonard and has never been found in the Word. It therefore seems to me that the beds which yielded these fossils are most probably in the upper part of the Leonard formation.

Several of the species discussed on the following pages have been studied by various authors, and extensive synonymies have accumulated for them. However, since these synonymies have recently been listed in full by Plummer and Scott (1937), Miller and Furnish (1940), and Miller (1944), I am not including them.

SYSTEMATIC PALEONTOLOGY

MEDLICOTTIA WHITNEYI Böse

From a single horizon and locality, Cooper obtained 11 completely silicified specimens that seem to belong in this species. These range in diameter from about 8 mm. to about 75 mm. (estimated), but most of them are small—seven are 11 mm. or less in diameter, and three more are less than 25 mm. in diameter. All are septate throughout and therefore represent only phragmacone.

Most of these specimens do not elucidate the details of the sutures clearly, but they illustrate very well the shape of the conch during ontogenetic development. The smaller specimens show that the adapical portion of the conch is about as wide as high. However, during early ontogenetic development, the height of the conch increases much more rapidly than the width, and at the same time the lateral zones become flattened and essentially parallel, whereas the ventral zone remains rounded. At a diameter of some 6 or 7 mm. the conch resembles in general physiognomy that of typical mature representatives of *Pronorites*. Orad of there the ventral zone rather gradually becomes concave, and the ventrolateral zones, which are rounded, develop slight nodes. As ontogenetic development proceeds the ventrolateral zones become narrower and narrower and gradually evolve into thin angular keels. At the same time the ventrolateral nodes become more and more prominent and then gradually disappear. They seem to have achieved their maximum development when the conch is some 10 or 11 mm. in diameter, and by the time it has attained a diameter of some 20 mm. they have become obsolete.

Occurrence.—Upper part of Leonard formation near the top of the slope on the northwest side of the road about one-half mile southwest of the old Word Ranch house in the Glass Mountains of Brewster County, Texas.

Repository.—U. S. National Museum, 111,636.

MEDLICOTTIA BURCKHARDTI Böse

Cooper's collections contain three specimens that are referable to this species. All are entirely silicified and only moderately well preserved. However, their characters, insofar as they can be determined, seem to coincide well with those of typical representatives of this species described by Böse, Plummer and Scott, and Miller and Furnish. All three of the specimens under consideration are septate throughout and therefore represent only phragmacone. The largest of them is about 78 mm. in diameter.

Occurrence.—Third limestone of the Word formation about 4 miles north-northeast of the Hess Ranch house in the Glass Mountains of Brewster County, Texas.

Repository.—U. S. National Museum, 111,647 (largest specimen) and 111,648 (two specimens imbedded in a block of limestone).

PSEUDOGASTRIOCERAS COOPERI Miller, n. sp.

Plate 6, figures 1, 2

One large and four moderate-sized specimens constitute the basis for this species. All five of these specimens came from the same horizon and locality, and all are completely silicified testiferous individuals.

The large specimen (pl. 6, figs. 1, 2) is chosen as the holotype. The preserved portion of it is estimated to have attained a maximum diameter of a little more than 100 mm. and a maximum height and width of conch of about 45 mm. and 65 mm., respectively. Not more than one-fourth of a volution of this holotype represents living chamber. The umbilicus is large and deep, and that of the holotype attains a maximum

diameter of almost 40 mm. The umbilical walls are very steep and the umbilical shoulders are abrupt.

With the exception of the outer volution of the holotype (and possibly the extreme adapical portion of the conch), the whorls are flattened laterally and rounded ventrally, and they are essentially U-shaped in cross section. Their lateral and ventral zones (but not the umbilical walls) bear prominent flat longitudinal lirae, which are relatively small and are very close together on the ventral portions of the conch but become progressively wider and farther apart on the lateral zones. Also each volution bears about five sinuous transverse constrictions, which form moderately deep, rounded ventral sinuses and similar ventrolateral salients. Between each of these constrictions are about four similar but shorter constrictions, which are confined to the region of the umbilical shoulders and give those shoulders a nodose appearance. None of these constrictions extends across the umbilical wall. On the outer volution of the holotype, the umbilical zones become distinctly flared, and they gradually lose both their longitudinal and their transverse markings.

As in other congeneric forms, each mature suture forms a broad prominently subdivided ventral lobe, a narrower rounded U-shaped first lateral saddle, a pointed hastate first lateral lobe, a broad, rounded, asymmetrical second lateral saddle, a small acuminate lobe on the umbilical wall, a broad, asymmetrical, rounded internal second lateral saddle, a rather deep, narrow, hastate internal first lateral lobe, a rounded U-shaped internal first lateral saddle, and a deep, narrow, hastate dorsal lobe.

Remarks.—The most distinctive character of this species is probably the change in shape and ornamentation of the umbilical portions of the adoral volution of large, fully mature specimens like the holotype. No lirated gastrioceratids have been described previously from the Leonard or its American correlatives, though they have long been known to occur in both younger and older strata on this continent and are abundant in the Artinskian (Leonard equivalent) in the Ural region.

Occurrence.—Upper part of Leonard formation near the top of the slope on the northwest side of the road about one-half mile southwest of the old Word Ranch house in the Glass Mountains of Brewster County, Texas.

Types.—U. S. National Museum, 111,645 (holotype) and 111,641 (paratypes).

PSEUDOGASTRIOCERAS ROADENSE (Böse)
Plate 6, figures 3–5; plate 7, figure 13

Cooper's collections from the Word formation contain five small (less than 15 mm. in diameter) and four moderate-sized representatives of this species. All but one of these are completely silicified and are entirely free of matrix. One of the small specimens (pl. 6, figs. 3, 4) and two of the medium-sized ones (pl. 6, fig. 5; pl. 7, fig. 13) are illustrated. They show clearly that the early volutions of this form are similar to those of *Pseudogastrioceras cooperi*, described above, but that the nodose character of the umbilical shoulders becomes obsolete during relatively early ontogenetic development.

Occurrence.—Third limestone of the Word formation on the northern slope of the hill on the southern side of Hess Canyon about 4 miles N. 35° E. of the Hess Ranch house in the Glass Mountains of Brewster County, Texas.

Repository.—U. S. National Museum, 111,638 (figured specimens) and 111,640 (unfigured specimens).

AGATHICERAS GIRTYI Böse
Plate 6, figure 6; plate 8, figures 4–6

This well-known species is represented in the collections under consideration by a dozen specimens, all of which are completely silicified and are essentially free of matrix. The preserved part of the largest of these specimens (pl. 8, fig. 5) is estimated to be about 25 mm. in diameter, and at its adoral end its conch is about 14 mm. high and about 17½ mm. wide. This specimen, like all of the others I am studying, is entirely septate and therefore represents only phragmacone. Although most of these specimens are exceptionally well preserved, a detailed study of them has not enabled me to add anything of consequence to the existing knowledge of the morphology of the shell.

Occurrence.—All of the specimens now being studied are from the Word formation in the Glass Mountains of Brewster County, Texas. Eight of them, including pl. 8, figs. 4–6, were collected by G. A. Cooper from the third limestone of the Word on the northern slope of the hill on the southern side of Hess Canyon about 4 miles N. 35° E. of the Hess Ranch house. The others were obtained by Harold Vokes (1) on the southern side of a spur extending northwest to B. M. 4973 on the eastern side of Gilliland Canyon (one specimen), and (2) from the second limestone of the Word on the main ridge extending into Hess Canyon north from Hill 5611 about one-half mile west of 103° 10′ (pl. 6, fig. 6; and two unfigured specimens).

Repositories.—U. S. National Museum, 111,635 (pl. 8, figs. 4–6) and 111,634 (five unfigured specimens)—all collected by Cooper; and American Museum of Natural History (pl. 6, fig. 6; and three unfigured specimens—all collected by Vokes).

ADRIANITES ADAMSI Miller and Furnish
Plate 7, figures 9, 10

The single specimen that I am referring to this species is an entirely silicified testiferous individual, all but the extreme adoral part of which is septate. It does not reveal the nature of its sutures, and therefore perhaps its identification should be regarded as tentative. However, the size and shape of its conch, and its surface markings, which are exceptionally well preserved, all agree almost precisely with those of the holotype of *A. adamsi.*

The maximum diameter attained by this specimen measures about 35 mm., and near its adoral end its conch is about 30 mm. wide and about 18 mm. high. At the adoral end of the penultimate volution the width and height of the conch measure about 18 mm. and 10 mm., respectively. As these measurements indicate, the conch is expanded orad fairly rapidly. The umbilical shoulders are not very definite, but the diameter of the umbilicus is equal to about one-sixth that of the conch. The longitudinal lirae on the surface of the test are relatively far apart on the ventral and lateral zones of the conch and are relatively close together on the ventrolateral and dorsolateral zones. The umbilical walls do not bear lirae.

Occurrence.—Third limestone of the Word formation on the northern slope of the hill on the southern side of Hess Canyon about 4 miles N. 35° E. of the Hess Ranch house in the Glass Mountains of Brewster County, Texas. The holotype, the only other known representative of this species, came from the first limestone of the Word near the Word Ranch house in the Glass Mountains.

Repository.—U. S. National Museum, 111,629.

ADRIANITES? sp.
Plate 8, figures 2, 3

The specimen represented by figures 2 and 3 on plate 8 is globular in shape and is septate throughout. Near its adoral end its maximum diameter measures about 21½ mm. and its conch is about 20 mm. wide and about 10 mm. high. Its umbilicus is small and deep, and its umbilical shoulders are rather abrupt. The maximum diameter attained by the umbilicus of this specimen measures about 4½ mm.

The surface of the test bears fine longitudinal lirae and very faint transverse markings, which presumably are growth lines. Also, near the midlength of the outer volution of this specimen there is a rather prominent transverse constriction that is very slightly sinuous.

The general shape, but not the details, of the sutures can be ascertained quite readily. They appear to consist of a prominently divided ventral lobe and between it and each umbilical shoulder about six rather small lateral lobes, which decrease in size progressively with increasing distance from the venter. The general course of the sutures is rather strongly arcuate, as in *Adrianites elegans* Gemmellaro of the Sosio beds of Sicily.

Remarks.—I am somewhat uncertain in regard to the affinities of this specimen. However, the general physiognomy of its conch, the lirate surface of its test, and all of the available data in regard to its sutures indicate a relationship to *Adrianites.* Accordingly, I am referring it with question to that genus.

Occurrence.—Upper part of Leonard formation near the top of the slope on the

northwest side of the road about one-half mile southwest of the old Word Ranch house in the Glass Mountains of Brewster County, Texas.

Repository.—U. S. National Museum, 111,639.

PERITROCHIA SKINNERI Miller, n. sp.

Plate 7, figures 5, 6

The single specimen on which this species is based is a slightly worn internal mold that was sent to me by John W. Skinner. This holotype is septate throughout and therefore represents only phragmacone. Its maximum diameter measures about 17½ mm., and near its adoral end its conch is about 9 mm. high and 12 mm. wide. The umbilicus is small and inconspicuous. No trace of surface ornamentation is discernible on the holotype.

FIG. 1—Diagrammatic representation of one of the adoral sutures of the holotype of *Peritrochia skinneri* Miller, n. sp., at a diameter of about 17 mm., ×10. Drawn by W. M. Furnish.

Each mature external suture consists of a prominently divided ventral lobe and on either side of it five lateral lobes. The general shape of the sutures is shown by text figure 1, but it seems probable that the details of the lobes would be somewhat different if the specimen had not been worn.

Remarks.—The sutures of this species are not at all closely similar to those of the only congeneric form known from the Leonard formation, *P. dunbari* Miller and Furnish. However, they are a great deal like those of *P. erebus* Girty of the Bone Spring limestone, which is generally regarded as the approximate stratigraphic equivalent of the Leonard.

Occurrence.—Upper part of Leonard formation at the Clay Slide, west-northwest of Iron Mountain in the Glass Mountains of Brewster County, Texas.

Holotype.—State University of Iowa, 3143.

STACHEOCERAS sp.

Plate 8, figures 7, 8

The general physiognomy and the shape of the internal sutures of the specimen represented by figures 7 and 8 on plate 8 indicate that it belongs in *Stacheoceras*. However, since the nature of its external sutures is not known, its specific affinities are uncertain. Superficially it seems to resemble *S. rothi* Miller and Furnish, the only previously described Leonard representative of the genus, but its umbilicus is larger than is that of the type specimens of that species.

The preserved portion of the specimen under consideration is estimated to have attained a diameter of about 40 mm. It is septate throughout and therefore represents only phragmacone. Near its adoral end, the conch is about 32 mm. wide and about 20 mm. high, and the umbilicus attains a maximum diameter of about 5 mm. No trace of surface ornamentation can be discerned, but on the penultimate volution there are three or four rounded transverse constrictions, which are slightly sinuous and are not particularly prominent. The shape of the dorsal and dorsolateral portions of the internal sutures is shown by text figure 2. The arcuate course of the sutures suggests a relationship to *S. mediterraneum* of the Sosio beds of Sicily.

Occurrence.—Upper part of the Leonard formation near the top of the slope on the northwest side of the road about one-half mile southwest of the old Word Ranch house in the Glass Mountains of Brewster County, Texas.

Repository.—U. S. National Museum, 111,630.

PERRINITES HILLI (Smith)
Plate 7, figures 7, 8

The collections under consideration contain many well-preserved representatives of this species. As is to be expected when a large number of conspecific specimens is available, a considerable amount of variation is apparent. However, all of the material now being studied comes within the limits of this species as established by Miller and Furnish in 1940. Most of the specimens are of moderate size, and the largest of them attains a diameter of only about 78 mm. All of them appear to be septate throughout and therefore to represent only phragmacone.

The specimen illustrated by figures 7 and 8 on plate 7 is noteworthy in that it has a particularly large umbilicus for this species. It is not possible to ascertain the precise shape of the sutures of this specimen, but insofar as I have been able to ascertain its sutures are rather primitive—presumably this specimen should be referred to the variety *tardus* of Miller and Furnish. Essentially all of the other specimens appear to belong in the typical variety, but the details of the sutures are not shown by many of them.

Occurrence.—This species is known to be widespread in the Western Hemisphere, but stratigraphically it is limited to the Leonard series. Representatives of it have been described from numerous localities in north-central and west Texas, central Oklahoma, south-central New Mexico, northern and southern Mexico (Coahuila and Chiapas), and probably northern Colombia.

The collections under consideration all came from the Leonard formation of the Glass Mountains of Brewster County, Texas. The specimen represented by figures 7 and 8 on plate 7 was found by Harold Vokes near the water tank just northwest of Iron Mountain. The rest of the material was collected by G. A. Cooper at the following two horizons and localities: (1) just above the contact of the old Hess and Leonard formations near Split Tank about 21 miles northeast of Marathon (50 specimens); and (2) in the upper part of the Leonard near the top of the slope on the northwest side of the road about one-half mile southwest of the old Word Ranch house some 17 miles north-northwest of Marathon (15 specimens, completely silicified).

FIG. 2—Diagrammatic representation, ×5, of the dorsal and dorsolateral portions of the internal suture of *Stacheoceras* sp. at a diameter of some 30 mm. Based on the specimen represented by figures 7 and 8 on plate 8.

Repositories.—American Museum of Natural History (pl. 7, figs. 7, 8) and U. S. National Museum, 111,642 (specimens from near Split Tank) and 111,644 (specimens from near old Word Ranch house).

WAAGENOCERAS GUADALUPENSE Girty
Plate 7, figures 1, 2

After studying many well-preserved representatives of *Waagenoceras* from west Texas and southwestern Coahuila, Miller and Furnish (1937) concluded that this species should be allowed considerable latitude. They proposed the varietal name *W. quadalupense thompsoni*, for forms with rather strongly compressed conchs and *W. quadalupense smithi*, for those that are

FIG. 3—Diagrammatic representation, ×5, of the external suture of a primitive representative of *Waagenoceras guadalupense thompsoni* at a diameter of about 17 mm. Based on the specimen represented by figures 1 and 2 on plate 7.

obese and subfusiform. Furthermore, they note that specimens from a single horizon and locality show a certain amount of variation in their sutures, and that in some individuals similar variations are to be found on opposite sides. They state that in some primitive representatives of this species at full maturity there are as few as four lateral lobes on each side of the conch and a divided fifth on each umbilical shoulder, but that in other specimens there are five lateral lobes in addition to the one on the umbilical shoulder.

The specimen represented by figures 1 and 2 on plate 7 has a relatively narrow conch for this genus, and therefore it should be referred to *W. guadalupense thompsoni*. This individual is particularly noteworthy in that even its adoral sutures form only three external lateral lobes on each side of the conch and a divided one on each umbilical shoulder. Furthermore, the general course of these sutures is directly transverse to the long axis of the conch; that is, the sutures are not arcuate as are those of most representatives of *Waagenoceras*. Thus, insofar as sutures are concerned, this specimen can be said to be the most primitive representative of *Waagenoceras* known. Its maximum diameter measures about 24 mm., and the adoral half volution of its conch is nonseptate and therefore represents living chamber. Its umbilicus attains a diameter of about 7 mm. and its umbilical shoulders are abrupt.

Occurrence.—All of the known representatives of this species came from the middle and upper portions of the Delaware Mountain formation and the Capitan limestone in the Guadalupe Mountain region of Culberson County, Texas, or from equivalent beds in the Valle de Las Delicias of southwestern Coahuila. The specimen represented by figures 1 and 2 on plate 7 came from the Capitan limestone of El Capitan Peak in the Guadalupe Mountains.

Repository.—American Museum of Natural History (pl. 7, figs. 1, 2).

WAAGENOCERAS DIENERI Böse
Plate 7, figures 3, 4, 11, 12

It is now recognized that there is essentially complete gradation between this species and *W. guadalupense*, but in general the sutures of *W. dieneri* consist of more elements than do those of that species. The specimens represented by figures 3, 4 and 11, 12, on plate 7 elucidate the shape of the sutures remarkably well, and in both of them there are six external lateral lobes on each side of the conch and a small lobe on the umbilical shoulder. In all available par-

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EXPLANATION OF PLATE 7

FIGS. *1, 2—Waagenoceras quadalupense thompsoni* Miller and Furnish. An almost complete internal mold, ×2, from the Capitan limestone, El Capitan Peak, Guadalupe Mountains, Texas. (p. 19)

3, 4—Waagenoceras dieneri Böse. A portion of a phragmacone, ×2, on which the sutures are exceptionally clear, from the Word formation on the south side of a spur on the east side of Gilliland Canyon extending northwest to B. M. 4973, Glass Mountains, Texas. (p. 20)

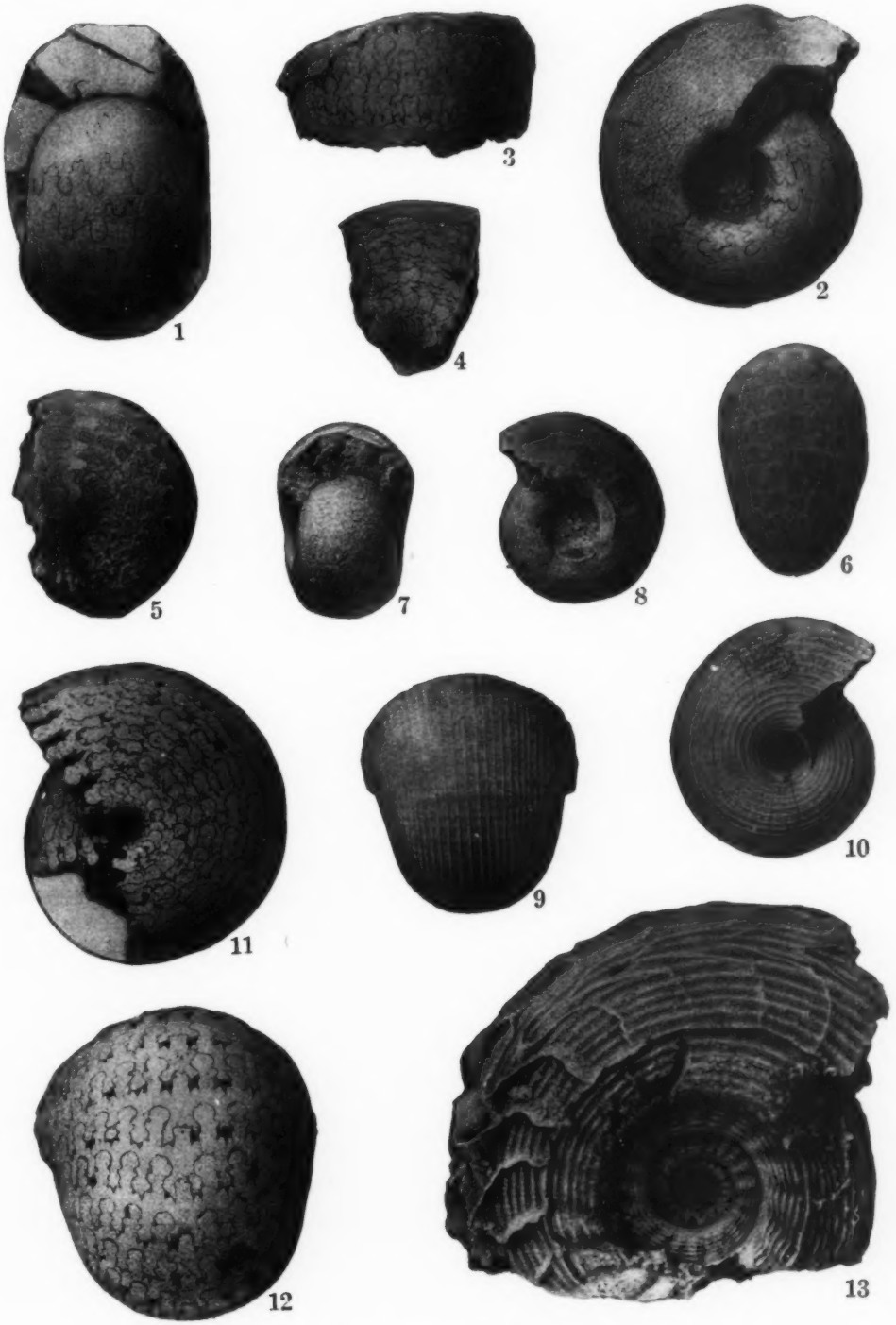
5, 6—Peritrochia skinneri Miller, n. sp. The holotype, ×2, from the upper part of the Leonard formation at the Clay Slide, west-northwest of Iron Mountain, Glass Mountains, Texas. (p. 18)

7, 8—Perrinites hilli tardus Miller and Furnish? A specimen, ×2, with a relatively large umbilicus, from the Leonard formation near the water tank just northwest of Iron Mountain, Glass Mountains, Texas. (p. 19)

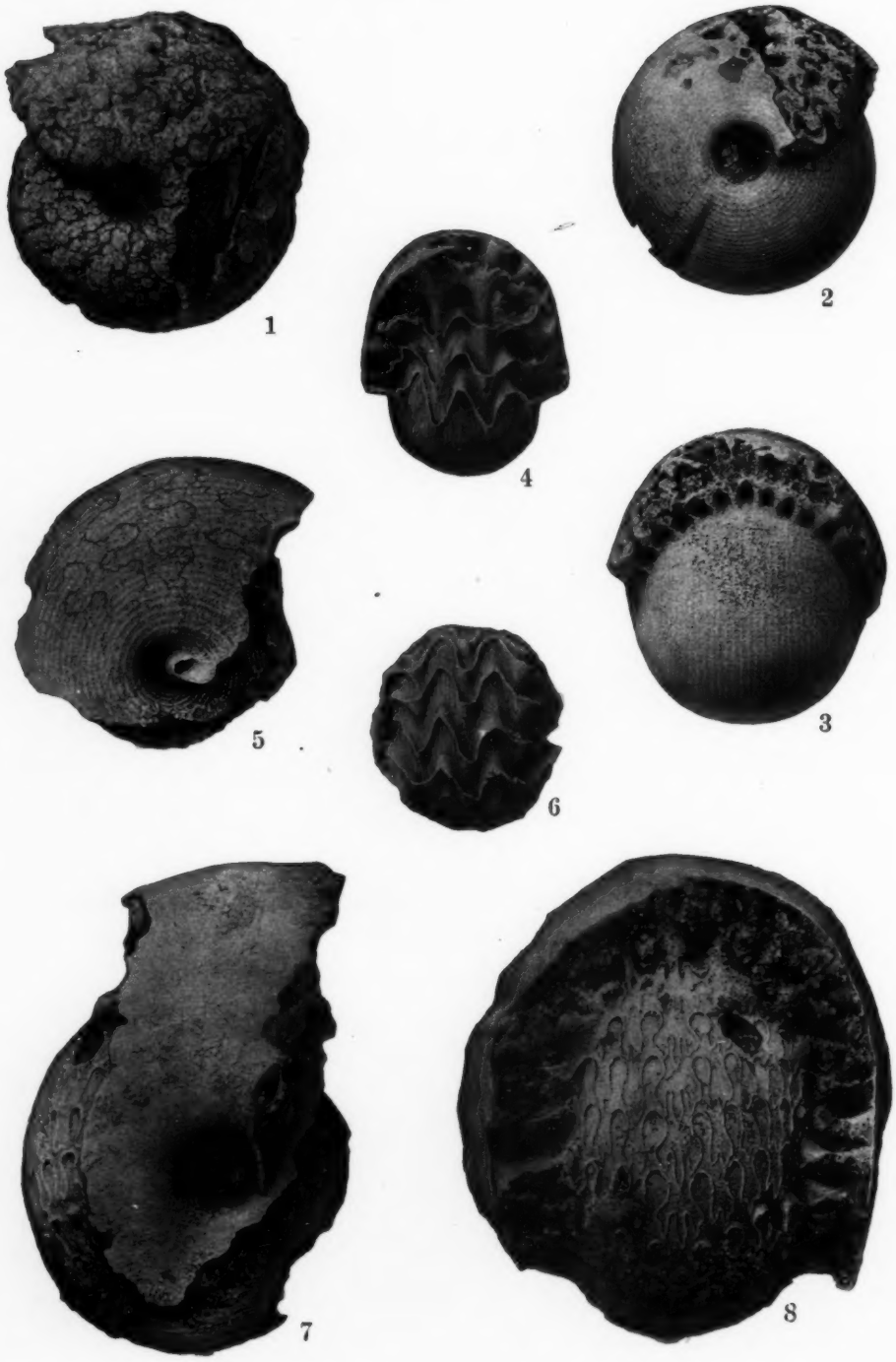
9, 10—Adrianites adamsi Miller and Furnish. An exceptionally fine silicified specimen, ×1, from the third limestone of the Word formation on the northern slope of a hill on the southern side of Hess Canyon about 4 miles N. 35° E. of the Hess Ranch house, Glass Mountains, Texas. (p. 17)

11, 12—Waagenoceras dieneri Böse. A well-preserved specimen, ×2, from the second limestone of the Word formation on the main ridge extending into Hess Canyon north from Hill 5611 about one-half mile west of the 103° 10′ line, Glass Mountains, Texas. (p. 20)

13—Pseudogastrioceras roadense (Böse). A silicified specimen, ×2, from the third limestone of the Word formation on the northern slope of a hill on the southern side of Hess Canyon about 4 miles N. 35° E. of the Hess Ranch house in the Glass Mountains of Brewster County, Texas. (p. 16)



Miller, Permian Ammonoids



Miller, Permian Ammonoids

ticulars, both of these specimens seem to be typical representatives of *W. dieneri*, and presumably they should be referred to the typical variety of that species, *W. dieneri dieneri*. Two other varieties are recognized, *W. dieneri girtyi* Miller and Furnish in which the sutures form one more external lateral lobe on each side of the conch than do those of equal-sized specimens of the typical variety, and *W. dieneri karpinskyi* in which the surface of the test is reticulate, bearing fine longitudinal and transverse lirae. Only the typical variety is represented in the collections now under consideration.

Occurrence.—All of the known representatives of this species came from the Word and Delaware Mountain formations of west Texas or from equivalent beds in southwestern Coahiula and northwestern Sonora. The collections now being studied contain specimens from the Word formation at the following three localities in the Glass Mountains of Brewster County, Texas: (1) on the south side of a spur on the east side of Gilliland Canyon extending northwest to Benchmark 4973 (pl. 7, figs. 3, 4); (2) on the main ridge extending into Hess Canyon north from Hill 5611 about ½ mile west of the 103° 10′ line (pl. 7, figs. 11, 12); and (3) about 4 miles north-northeast of the Hess Ranch house—at the second locality the specimen came from the second limestone of the Word formation, and from the last locality there are six specimens from the third limestone of that formation.

MANUSCRIPT RECEIVED APRIL 3, 1944.

Repository.—American Museum of Natural History (pl. 7, figs. 3, 4 and 11, 12); and U. S. National Museum, 111,632, 111,633, and 111,646 (six unfigured specimens).

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EXPLANATION OF PLATE 8

FIGS. *1*—*Waagenoceras dieneri* Böse? A rather poorly preserved silicified specimen, ×3, from the Monos formation at El Antimonio west of Caborca, Sonora. (p. 20)

2, 3—*Adrianites?* sp. A silicified testiferous specimen, ×2, from the upper part of the Leonard formation near the top of the slope on the northwest side of the road about one-half mile southwest of the old Word Ranch house in the Glass Mountains of Brewster County, Texas. (p. 17)

4–6—*Agathiceras girtyi* Böse. Three silicified specimens, ×2, from the third limestone of the Word on the northern slope of a hill on the southern side of Hess Canyon about 4 miles N. 35° E. of the Hess Ranch House in the Glass Mountains of Brewster County, Texas. (p. 16)

7, 8—*Stacheoceras* sp. An incomplete silicified phragmacone, ×2, from the same horizon and locality as the specimen represented by figures *2, 3*. (p. 18)

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A PERMIAN AMMONOID FROM SONORA

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ABSTRACT—A rather poorly preserved representative of *Waagenoceras dieneri* Böse is illustrated and described from northwestern Sonora. It is concluded that the beds from which it came (Monos formation) are to be correlated with the Word formation of the Glass Mountains and equivalent beds elsewhere in west Texas and in Coahuila.

DURING the spring of 1943, G. A. Cooper of the U. S. National Museum and Ing. Alberto Allerano of the Geological Institute of Mexico collected from a sequence of Permian strata (Monos formation) at El Antimonio, west of Caborca in northwestern Sonora. They secured many brachiopods but few representatives of any other phylum. They were unable to find any fusulinids although some have been reported from this part of Mexico, and they obtained only one ammonoid.

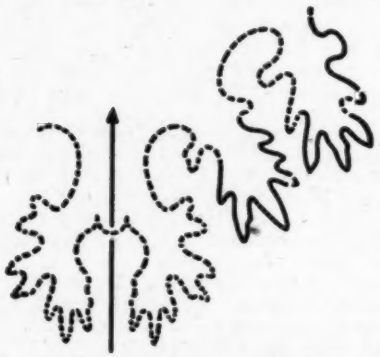

FIG. 1—Diagrammatic representation, ×10, of part of the external suture of *Waagenoceras dieneri* Böse from northwestern Sonora at a diameter of some 12 mm. Only the portions of the suture represented by solid lines were ascertained, and these are not accurate in detail.

This ammonoid (pl. 8, fig. 1) is completely silicified, and its preservation leaves much to be desired. However, both W. M. Furnish and I believe that the configuration of its shell, the number of elements in its sutures, and the arcuate form of the margins of its septa indicate clearly that it is referable to *Waagenoceras dieneri* Böse. Also, some of the details of its sutures were exposed on the side of the conch not shown by figure 1 on plate 8, and these confirm the identification. The number of lateral lobes in the sutures of this specimen suggests a relationship to the Coahuila representatives of *W. dieneri* rather than to those of the Word formation of west Texas, but all of them are of approximately the same age.

W. dieneri has for some years been regarded as an excellent index to the Word horizon. However, in the Delaware Mountains of west Texas and probably in the Valle de Las Delicias of southwestern Coahuila, it occurs in both the Word and the Capitan horizons.

Cooper has written me that the brachiopods found in association with this Sonora ammonoid suggest some that he has from the Word formation. This observation, together with the fact that *W. dieneri* is abundant in the Word and equivalent beds and is rare in the Capitan horizon, leads me to the conclusion that the beds in Sonora which yielded this specimen are of Word age.

The matrix in which the specimen under consideration was imbedded is a dense, fine-grained, dark-gray limestone. The specimen is septate throughout and therefore represents only phragmacone. Its maximum diameter measures about 16 mm., and its whorls appear to be almost twice as wide as high. The label which accompanies this specimen indicates that it came from the lower *Spiriferina* beds at the "top of east knob of Mill Hill, San Francisco, 2 km. north-northeast of El Antimonio, Sonora." It is to be deposited in the U. S. National Museum, where its catalogue number is 111623.

ADDENDUM

Since this manuscript was completed, that is, during the summer of 1944, Cooper found another ammonoid in the *Spiriferina* zone northeast of El Antimonio. This specimen, which will be illustrated and described in detail, is fairly well preserved, and its affinities are clearly with *Waagenoceras dieneri* Böse.

MANUSCRIPT RECEIVED APRIL 3, 1944.

JOURNAL OF PALEONTOLOGY, VOL. 19, NO. 1, PP. 23–29, 4 TEXT FIGS., JANUARY 1945

A NEW SAUROPOD DINOSAUR FROM THE UPPER CRETACEOUS OF MISSOURI

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ABSTRACT—Fragmentary remains of the dinosaur *Neosaurus missouriensis* Gilmore, n. gen., n. sp., are described and their geological occurrence is recorded. This is the first known discovery of dinosaur remains in Missouri. It adds one more to the small number of occurrences of sauropod dinosaurs from the Upper Cretaceous series of North America.

THE United States National Museum has come into possession of a fragmentary dinosaur specimen of more than ordinary interest in being the first of this great group of reptiles to be discovered in the state of Missouri (Branson, 1942). This specimen contributes little to a better understanding of the Dinosauria, but its unique occurrence seems worthy of detailed record. For that reason, Mr. Dan R. Stewart of the staff of the State of Missouri Geological Survey and Water Resources, who was the first to recognize the scientific importance of this specimen, was invited to contribute the brief history and account of its geological occurrence which forms the first part of this paper.

The second part, by the senior author, is given over to a detailed description of the specimen with a brief discussion of its biological relationships.

PART I—GEOLOGY OF THE MISSOURI DINOSAUR OCCURRENCE

By DAN R. STEWART

Early in the spring of 1942 the Missouri Geological Survey made a thorough examination of the clays along the southeastern flank of the Ozarks to determine their possible origin and stratigraphic position. This work has been continued to the present time and has yielded the following results: (1) the discovery of dinosaur bones near Glen Allen, Bollinger County, Missouri, and (2) the proving of an overlap of considerable magnitude of Upper Cretaceous on the Ozark region.

The dinosaur bones were found imbedded in a black plastic clay, which was encountered at a depth of 8 feet in a shallow well dug at the farmhouse of Mrs. Lulu Chronister. The Chronister residence is situated near the center of sec. 26, T. 31 N., R. 9 E., in a small valley 0.6 of a mile northwest from the Glen Allen-Patton road, about one mile north of Glen Allen, Bollinger County, Missouri. This area lies within the Ozark Province, 30 miles west from Cape Girardeau, Missouri, and 12 miles northwest from the Cape Girardeau-Poplar Bluff Escarpment, which separates the lowland district of southeastern Missouri from the Ozarks proper.

GENERAL GEOLOGY

Paleozoic

The area surrounding the Chronister house lies entirely within the belt of outcrop of the Roubidoux sandstone of Lower Ordovician or Canadian age. In this portion of the Ozarks weathering has been carried to a considerable depth leaving the hillsides covered with fragments and boulders of residual sandstone and chert. As a result outcrops are very seldom found and are restricted to the bottoms of the deeper valleys. The small branch which flows southwestward just north of the Chronister house is completely choked with chert and sandstone debris making detailed geologic mapping extremely difficult.

To further complicate matters in this vicinity is the unique type of faulting so common in this area. These faults consist of a series of long, narrow dropped blocks, having a probable northwest-southeast strike. The heavy cover of residual chert and sandstone makes detailed examination of them almost impossible. They were completely truncated before the present topog-

raphy was developed, and consequently only in a few places do they make themselves evident. Where exposed, they exhibit themselves as a jumbled mass of boulders representing torn fragments of Lower Ordovician, Middle Ordovician, Silurian and Devonian formations. The movement on these faults, considering the normal thicknesses of the formations involved, would in some places, exceed 1,500 feet. The remarkable thing about them is that a few hundred feet on either side, along a line normal to their strike, undisturbed Lower Ordovician rocks are seen in place. This faulting is thought to be related to the post-Middle Devonian faulting of St. Genevieve County; however, in the Glen Allen area and elsewhere along the southeastern flank of the Ozarks, recurrent movements along these faults have taken place, dropping the Upper Cretaceous sediments down below their normal level and thus preserving them from erosion.

One of these narrow fault blocks passes directly under the Chronister residence. Boulders of lower Plattin limestone (Middle Ordovician) and dark blue-black, plastic Cretaceous clay may be seen cropping out around the house. The well the Chronister's attempted to dig bottomed on a large mass of broken lower Plattin limestone and failed to provide an adequate water supply.

Upper Cretaceous

In general the Upper Cretaceous sediments of the southeastern Ozark area have been removed by post-Tertiary erosion; most of those that have been preserved occur as a thin veneer capping the higher ridges and plateaus. Some occupy pockets in old solution channels associated with fault blocks along which recurrent movements have taken place. Outcrops are very few and difficult to find, since most of the area is covered to depths as great as 50 feet with Tertiary rubble consisting of reworked chert and sandstone fragments. Some of the deeper highway cuts along the hilltops show small patches of white and red plastic clay, orange unconsolidated sand, or rounded case-hardened sandstone boulders. The bleaching of these outcrops gives them the appearance of having been deeply weathered.

In the areas where faulting or deep solution channels have allowed the Upper Cretaceous sediments to be brought down below the zone of surface weathering, the lithology is quite different, being more like the typical Cretaceous section as exposed in the Crowley's Ridge area to the southeast. The clays are dark-brown to black and contain occasional stringers of interbedded fine white micaceous sand. The sands are fine to medium-grained, usually somewhat micaceous, and range in color from white to deep orange. At least two occurrences of these dark-colored clays have been mined for use in ceramics, and the white clays of the upper weathered zone constitute the kaolins of the southeastern Ozark area. Prospect drilling has shown some of these deposits to exceed 150 feet in thickness.

Correlation of these sediments in the Ozarks with the known Upper Cretaceous of the Crowley's Ridge area can be based only on lithologic similarities. The color, texture and general appearance of the unweathered material is identical with the beds immediately underlying the Owl Creek formation (Upper Cretaceous) of southeastern Missouri. On this basis they would be correlated with the McNairy sand member of the Ripley formation.

THE CHRONISTER WELL

The Chronister farmhouse is situated at the foot of a steep slope on the southeast side of a small valley trending southwestward. It rests on the remnants of an eroded terrace, which is approximately 10 feet higher than the valley floor. The well is located a few feet southwest from the house, and is of the open type, being about 5 feet in diameter and 24 feet deep. The Chronister's dug this well in the early spring of 1942, but abandoned it when sufficient water was not found.

The dinosaur bones were encountered in a bed of dark blue-black plastic clay having a thickness of 9 feet. This bed is overlain by 7 feet of yellow to brown surface clay and gravel, and underlain by a dark-gray, dense, almost lithographic limestone of the lower Plattin formation. The bones that were recovered from the well were saved by Mrs. Lulu Chronister, who noticed their unusual size and shape.

In April 1942, when the junior author was searching this valley for clay outcrops, Mrs. Chronister called his attention to the bones she saved from their well. Realizing the rarity of bones of this type in a clay that appeared to be of Upper Cretaceous age, he immediately obtained permission for a loan of one vertebra. Later in May 1942 he returned to this locality and borrowed all the remaining bones except one, which had been given to a relative. This collection was forwarded to Dr. L. W. Stephenson of the United States Geological Survey for examination by Mr. C. W. Gilmore of the United States National Museum.

No outcrops of rocks in place have been found in the Chronister valley with the exception of a few boulders of Plattin limestone located immediately behind their house. An examination of the hillsides and along the creek have shown nothing but residual sandstones and cherts of the Roubidoux formation. The finding of Lower Plattin limestone, 20 miles west of its normal outcrop belt, suggests a dropped-block fault of considerable magnitude.

The clay containing the dinosaur bones is similar to the unaltered, highly organic clays of the Upper Cretaceous sediments along Crowley's Ridge. The occurrence of this clay at such a low elevation (540 feet above sea level) associated with a Paleozoic fault, and in an unweathered condition, suggests that recurrent movement along this fault must have taken place after the close of the Cretaceous period, allowing the clay to be dropped down below the zone of recent weathering.

The log of the Chronister's well is as follows:

Log of well on Mrs. Lulu Chronister's farm, 1 mile north of Glen Allen, Bollinger County, Missouri, near center of sec. 26, T. 31 N., R. 9 E., approximately 540 feet above sea level.

	Feet
Quaternary system (Pleistocene and Recent):	
Clay, yellow to brown, and gravel	7
Cretaceous system (Gulf series, McNairy sand member of the Ripley formation):	
Clay, blue to black, very plastic, containing the dinosaur bones	9
Ordovician system (Mohawk series, Lower Plattin formation):	
Limestone, dark gray, dense, almost lithographic in texture, with thin oolitic beds	8
Total depth	24

PART II—DESCRIPTION AND DISCUSSION OF THE MISSOURI DINOSAUR

By CHARLES W. GILMORE

The specimen on which the present paper is based consists only of caudal centra that in the ordinary course of events would be considered too meager for generic designation, but in view of the uniqueness of both its geographical and geological occurrence the name *Neosaurus missouriensis* is proposed for its reception.

Order DINOSAURIA
Suborder SAUROPODA
Family CAMARASAURIDAE?
Genus NEOSAURUS Gilmore, n. gen.

Caudal vertebrae amphicoelus; centra longer than wide; ends having concave central areas decorated with radiating ridges and depressions surrounded by a flattened peripheral border; chevron facets only on posterior ends.

NEOSAURUS MISSOURIENSIS Gilmore, n. sp.
Figures 1–3

Type.—U.S.N.M. 16735, consisting of 13 caudal centra and two unidentified fragments. Collected in 1942, by Mrs. Lulu Chronister.

Locality.—Chronister farm, sec. 26, T. 31 N., R. 9 E., about 1 mile north of Glen Allen, Bollinger County, Missouri.

Horizon.—McNairy sand member, Ripley formation, Upper Cretaceous.

Description.—The specimen, U.S.N.M. 16735, consists of 13 caudal centra and two unidentified fragments. A fourteenth caudal was given to a relative by Mrs. Chronister and up to this time it has not been available for study. Unfortunately all of the neural arches are missing, though the freshness of the fractured surfaces appears to indicate they were present when the vertebrae were first discovered. Other than the loss of these parts the bones are in excellent preservation.

The centra are amphicoelus, longer than wide, with sides angularly rounded vertically, and shallowly concave from end to end. The sides are divided subequally by a low longitudinal ridge that becomes progressively less conspicuous in a posterior direction. The ventral surfaces are flattened ex-

FIG. 1—*Neosaurus missouriensis* Gilmore. Type. U. S. N. M. 16735. Caudal vertebrae viewed from left side. *Sec*, point where section shown in fig. 3, was made. About one-seventh natural size.

cept at the posterior end, where it is scooped out between the weakly developed chevron facets as shown in figure 2-E.

Viewed from the ends the centra are hexagonal in outline. The articular faces of these ends have a flattened peripheral border surrounding a well-defined central concave center whose surface is decorated with radiating, irregularly placed bumps and depressions (see figs. 2-A and 2-C), the area of attachment for the intercentral ligaments. These distinctive articulating surfaces are present on both ends of all of the vertebrae, except the smallest one, which lacks the flattened peripheral border.

The regular diminution in size (see table of measurements) appears to indicate that 12 of the 13 vertebrae form a continuous series as shown in figure 1.

That this series is from the midlength of the tail is indicated not only by their size but also by the complete absence of transverse processes. Examination of the table of measurements shows the centra to decrease in height in a posterior direction much more rapidly than in transverse diameter, thus suggesting this portion of the tail to have been more or less rounded in life.

On the ventral surface of the centra usually at about midlength, single but sometimes in pairs, are small foramina that lead into the interior of the bones. Their occasional absence apparently indicates a feature of little consequence, though mention is made of them here for the reason of their rare occurrence in other dinosaur caudals.

Sectioning of a centrum (fig. 3) discloses petrifaction to be incomplete, that is, the cancellous internal structure is not filled with mineral matter but remains open as in life. In a way this confirms the Upper Cretaceous age of the fossil, as this condition often prevails in dinosaur bone from such well-established horizons as the Belly River and Lance, but rarely if at all in those from older formations.

That these vertebrae pertained to an adult individual is indicated by the complete coalescence of the neural arches to their respective centra. So complete is this union that the course of the sutures can no longer be traced in any of the vertebrae.

The smallest centrum preserved has a length of 69 mm., and if the same regular

MEASUREMENTS OF CAUDAL CENTRA IN MILLIMETERS

	1	2	3	4	5	6	7	8	9	10	11	12
Greatest length of centrum	91	91	90	87.5	87.5	87	86	85	83	82	79	78
Greatest width posterior end	87	86	85	—	83	76	78	73.5	69	67.5	—	65*
Greatest height (center) posterior end	91	90	86	—	78	67	—	65	60	60	57*	53*

*=estimated

diminution in length continues posterior to those shown in figure 1, this vertebra would be either the sixth or the seventh posterior to the last of that series. Measurements taken on the posterior end show the height and width to be subequal. The ends also differ from those more anteriorly by the absence of the flattened peripheral border, and the less-distinct chevron facets.

That these caudal centra pertain to a member of the Reptilia is clearly evident. Furthermore, their size indicates an animal having a long tail, and this fact is sufficient in itself to eliminate from consideration all known North American fossil Reptilia except the Dinosauria. Should it be thought that some of the exceptionally large individuals of the Mososauria or of the Pleisiosauria might have been of sufficient stature to accommodate these vertebrae in the tail, the procoelus centra of the former and the amphiphlatan vertebrae of the latter would be sufficient to disbar these caudals from such consideration.

Turning now to the Dinosauria, it is found there are 10 families that include Upper Cretaceous dinosaurian genera. Of these the Coeluridae, Dinodontidae and Ornithomimidae, in fact, all representatives of the Theropoda, may be at once dismissed from consideration on the basis of bone structure alone. Carnivorous dinosaur bone is composed of an outer layer of hard, dense bone, that in breakage scales off in onionlike layers. Neither of these characteristics are to be observed in the bones of the Chronister specimen.

A cross section of one of the caudal centra

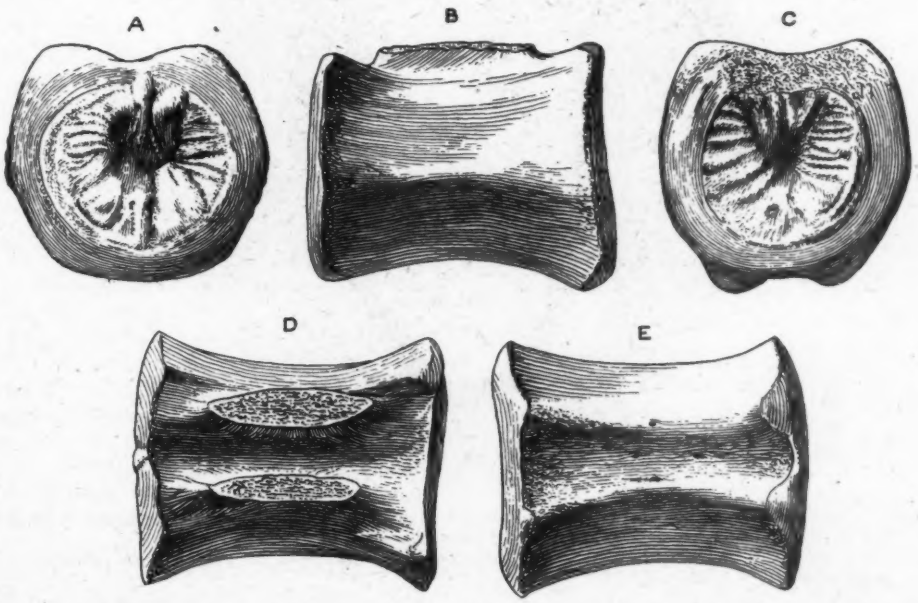

FIG. 2—*Neosaurus missouriensis* Gilmore. Type. U. S. N. M. 16735. Third caudal centrum from the left in figure 1. *A*, anterior end; *B*, left side; *C*, posterior end; *D*, dorsal side; *E*, ventral side. All figures about one-half natural size.

FIG. 3—*Neosaurus missouriensis* Gilmore. Transverse section of median caudal centrum, U.S.N.M. 16735, ×1. Section from near anterior end as indicated in fig. 1.

FIG. 4—*Antrodemus fragilis* (Marsh). Section taken near the middle of the vertebrae to show the dense outer layer. U.S.N.M. 8367, ×1.

(fig. 3) not only shows this dense, peripheral layer to be absent, but in most places the open cancellous character of the internal structures continues outward to the very surface of the bone. These differences in structure between the caudal vertebrae of carnivorous and herbivorous dinosaurs are clearly illustrated in figures 3 and 4.

That the affinities of the present specimen cannot lie in the Protoceratopsidae, Cera-

topsidae or Nodosauridae are shown by the fact that all of the animals included in these three families have relatively short tails, made up of caudals having comparatively short centra. Not only are the caudal centra distinctly unlike those under discussion, but the shortness of the tails makes the inclusion of the present series of 12 a physical impossibility.

Likewise the Hypsilophodontidae, represented in America by the genus *Thescelosaurus*, can be dismissed from consideration for the reason that all of the known representatives of this family are relatively small creatures having light skeletons and slender tails.

In the Hadrosauridae, however, there are representatives of sufficient size to absorb a series of caudals like those under discussion, but there are certain structural peculiarities, as I will presently attempt to show, which appear to indicate that the Missouri specimen can not pertain to this family.

Examination of the midcaudal region of many genera of the Hadrosauridae appears to establish the fact that all have relatively shorter centra, but also they are in agreement in having both lower ends of the centra bevelled for the articulation of the chevron bones. This bevelling greatly shortens the ventral profile, which is usually concave. The more elongate centra of the Chronister specimen, with the possible exception of *Hypsibema crassicauda* Cope, and the presence of chevron facets only on the posterior end appear sufficient to show that these vertebral centra do not pertain to a member of the Hadrosauridae.

Through the above process of elimination this specimen falls naturally into the suborder Sauropoda, a berth that appears to be in accord with its main characteristics.

Up until the year 1921 it was the accepted belief that the Sauropoda in North America had become extinct prior to Upper Cretaceous time. In that year a restudy (Gilmore, 1921a) of the Arundel fauna of Maryland seemed to show it to be Upper Cretaceous in age rather than Jurassic as previously thought. Thus the Sauropod genus *Astrodon* (*Pleurocoelus*) showed them to have continued on into the Upper Cretaceous. Later in this same year this idea was given additional support by the discovery (Gilmore, 1921b) of sauropod remains (*Alamosaurus*) in the Upper Cretaceous (Ojo Alamo formation) of New Mexico. In 1937, this fact was established beyond all question of doubt by the finding (Gilmore, 1938) of a partial skeleton of *Alamosaurus* in the North Horn formation of the Upper Cretaceous of Utah.

In view of the now-established fact that representatives of the Sauropoda did live on into the Upper Cretaceous, the present discovery should occasion no particular surprise on that score. Fortunately the two American Upper Cretaceous genera, *Alamosaurus* referred to the Titanosauridae and *Astrodon* (*Pleurocoelus*) assigned to the Brachiosauridae, have caudal vertebrae available for comparison with the Missouri specimen. These demonstrate at once that it could not pertain to either. The caudal centra of *Alamosaurus* are strongly procoelus[1] throughout the series, as contrasted with the amphicoelus vertebrae of *Neosaurus*. The tail of *Astrodon*, at this time, is known only from scattered vertebrae, and although they agree in being amphicoelus, the centra are relatively shorter, without lateral ridge on centrum, and without flattened peripheral ring on the articular ends. The small size of the known individuals is a further indication of their distinctness.

Although the meager character of the type of *Neosaurus* does not allow a proper evaluation of its family relationships, it is tentatively assigned to the Camarasauridae. This assignment is made on the inadequate basis of the general make up of these amphicoelus vertebrae, which have their nearest counterparts in such genera as *Camarasaurus* and *Apatosaurus*.

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[1] It should be explained that the unpublished information used here relating to *Alamosaurus* has been derived from a partial skeleton of *Alamosaurus*, U. S. N. M. 15560, from the Upper Cretaceous of Utah. The description of this specimen has been in manuscript for more than three years, but, owing to restrictions due to the war, it is still awaiting publication.

PUBLISHED BY PERMISSION OF THE SECRETARY OF THE SMITHSONIAN INSTITUTION. MANUSCRIPT RECEIVED SEPTEMBER 28, 1943.

JOURNAL OF PALEONTOLOGY, VOL. 19, NO. 1, PP. 30–34, 1 TEXT FIG., JANUARY 1945

A NEW EOCENE LIZARD FROM WYOMING

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ABSTRACT—An incomplete skull with articulated lower jaws, found by the Princeton Scott Fund Expedition of 1931 in Wyoming, is the first record of an amphisbaenid lizard from the Lost Cabin, the higher member of the Wind River formation. The specimen represents a new species, for which the name *Ototriton minor* is proposed, and its study provides new information about the genus.

IN 1919 Loomis erected a new genus and species, *Ototriton solidus*, in the belief that the specimen (Amherst College Museum) he described, consisting of a skull and part of a lower jaw from the Lysite member of the Wind River formation, represents an amphibian. Its amphisbaenid affinities were discerned later (Gilmore, 1928, p. 44) and at the same time the previously named species *Glyptosaurus anceps* Marsh, 1871, (from horizon B of the Bridger formation) was provisionally referred to Loomis' genus.

As systematic knowledge of Marsh's species developed, the material upon which it was based diminished. The history of the treatment of the specimens typifies some of the difficulties and vagaries of taxonomic practices of an earlier day. Marsh "made a communication on some new reptiles and fishes from the Cretaceous and Tertiary formations" before the Philadelphia Academy of Natural Sciences on April 25, 1871, as recorded in the Proceedings of the Academy for that year (pp. 103–5). In this communication "the generic name *Glyptosaurus* was proposed" for "a new and peculiar genus of lizards." Three species were diagnosed by cranial characteristics and a "much smaller species, probably 2 feet in length, and perhaps generically distinct, was indicated by a number of vertebrae, and jaws, and possibly by some scutes. This was called *G. anceps*."

The signature encompassing Marsh's report was "certified" as of July 11. Between the dates of the communication and the signature certification Marsh described the species in the American Journal of Science in a manuscript dated May 5 and published in June. At this time he mentioned "numerous fragmentary remains," remarked that "the teeth are pleurodont," and that "some of the characters . . . point toward a different genus," and gave dimensions for a "posterior dorsal vertebra."

Douglass in 1908 laconically stated, about the species, "Only vertebrae known. They represent an animal about 2 feet long."

By 1928 (Gilmore, p. 46) the "type mamerial . . . consisted of a dorsal vertebra" that "does not belong to the genus *Glyptosaurus*, a fact of which Marsh was apparently cognizant." The fate of the other specimens to which Marsh alluded was unknown. Gilmore referred another dorsal vertebra, also in the Yale collection and also from the Bridger, to the species. Ten years later Gilmore (1938a, p. 88) compared the type of *anceps* with the type, also a vertebra, of *Lestophis crassus* and decided that the two species were congeneric amphisbaenids. *Lestophis* had been proposed by Marsh in 1885 when he discovered that his previous name for the genus, *Limnophis* (1871), was preoccupied. Schmidt in 1927, unaware that Marsh had already changed the name, noted the preoccupation of *Limnophis* and proposed renaming the genus *Paleoboa*. In 1942 Camp, Taylor, and Welles followed Gilmore in transferring *anceps* from *Ototriton* to *Lestophis* but assigned *Ototriton* to the *Dolichosauridae* and *Lestophis* to Sauria, incertae sedis.

At present the amphisbaenid genus *Ototriton* includes two species, *solidus*, and *minor*, the latter herein characterized. The two species of *Lestophis*, *L. crassus* and *L. anceps*, are for convenience classified as amphisbaenids, in the hope that additional materials will some day disclose their true affinities. No complete skeletons of fossil

amphisbaenids have been found. When they are discovered the study of their limbs and limb girdles will be of particular interest as clues to the rates and modes of reduction of these elements in members of the family.

In addition to the two species placed in *Ototriton* and to the dubious pair, *Lestophis anceps* and *L. crassus*, five other species of North American fossil amphisbaenids are known, all of Oligocene age. Four of these, *hatcherii*, *minutus*, *sternbergii*, and *coloradoensis* are placed with the living species *floridana* in the genus *Rhineüra;* the other, *antiqua*, represents the monotypic genus *Hyporhina*.

The known geological distribution of American Tertiary amphisbaenids is as follows:

Oligocene, Brule formation:
Whitneyan, *Rhineüra hatcherii*, *Hyporhina antiqua*.
Orellan, *Rhineüra minutus*, *R. hatcherii*, *R. sternbergii*.
Oligocene, Chadron formation (Horsetail Creek facies):
Chadronian, *Rhineüra coloradoensis*.
Eocene, Bridger formation (Black's Fork member):
Bridgerian, *Lestophis anceps*, *L. crassus*.
Eocene, Wind River formation:
Wasatchian (Lost Cabin member), *Ototriton minor*.
Wasatchian (Lysite member), *Ototriton solidus*.

All of the known specimens of these nine species have been collected from a relatively small region within the area between 102°–111° west longitude and 40°–44° north latitude, in South Dakota, Wyoming, Colorado, and Nebraska.

Only one other fossil amphisbaenid has been described, *Crythiosaurus mongoliensis* Gilmore, 1943, from the Hsanda Gol Oligocene of Inner Mongolia.

Although the type of *O. solidus* and that of *O. minor* are from localities only about 20 miles apart, near the center of Wyoming, they come from different counties, the former from Fremont County, and the latter from Natrona County. These field data are here emphasized because the type locality of *O. solidus* has been reported erroneously as Bighorn County (Gilmore, 1928, p. 43).

The following synopsis of structures has been framed to indicate the most significant known cranial distinctions of the species listed. (*Rhineüra coloradoensis* and *Lestophis anceps* and *crassus*, which are represented only by vertebrae, are of course omitted.)

SYNOPSIS OF CRANIAL CHARACTERISTCS OF NORTH AMERICAN FOSSIL AMPHISBAENIDS

I. Postorbital arch; prefrontal excluded from orbital border; no sagittal ridge; pineal foramen; one premaxillary tooth, four maxillary teeth, six dentary teeth. . . . . *Hyporhina*

II. No postorbital arch; prefrontal forms part of orbital border; no pineal foramen.
  A. Three premaxillary teeth; seven maxillary teeth; well-developed sagittal ridge; sphenoids not keeled between anterior medial wings of pterygoids; strong lateral projection of supraoccipitals above fenestra ovalis; eight dentary teeth. . . . . *Ototriton*
    1. Comparatively large (type skull about 32 mm. long). . . . . *O. solidus*
    2. Comparatively small (type skull about 17.6 mm. long). . . . . *O. minor*
  B. One premaxillary tooth; sphenoid bones keeled between anterior medial wings of pterygoids. Supraoccipital smoothly rounded above fenestra ovalis; seven[1] dentary teeth. . . . . *Rhineüra*
    1. Six maxillary teeth.
      a. No diastemata in maxillary tooth series (or short one between 3–4); sagittal ridge developed, but incomplete posteriorly; type skull about 12.8 mm. long. *R. hatcherii*
      b. Diastema between third and fourth maxillary teeth, no sagittal ridge; type skull about 7.8 mm. long. . . . . *R. minutus*
    2. Five maxillary teeth, diastema between second and third, sagittal ridge developed but incomplete posteriorly; type skull about 8 mm. long. . . . . *R. sternbergii*

[1] Number not known in *R. minutus*.

Family AMPHISBAENIDAE
Genus OTOTRITON Loomis, 1919
OTOTRITON MINOR Gilmore and Jepsen, n.sp.
Figure 1

Type.—Princeton Museum no. 13460, a skull (lacking much of its roof) and articulated lower jaws. Collected in 1931; Alkali Creek, 5 miles northwest of Arminto, Natrona County, Wyoming, from the Lost Cabin member (*Lambdotherium* zone) of the Wind River formation, late Wasatchian, early Eocene.

Discussion.—There are many structural differences which serve to distinguish the species of *Ototriton* from those of *Rhineüra*

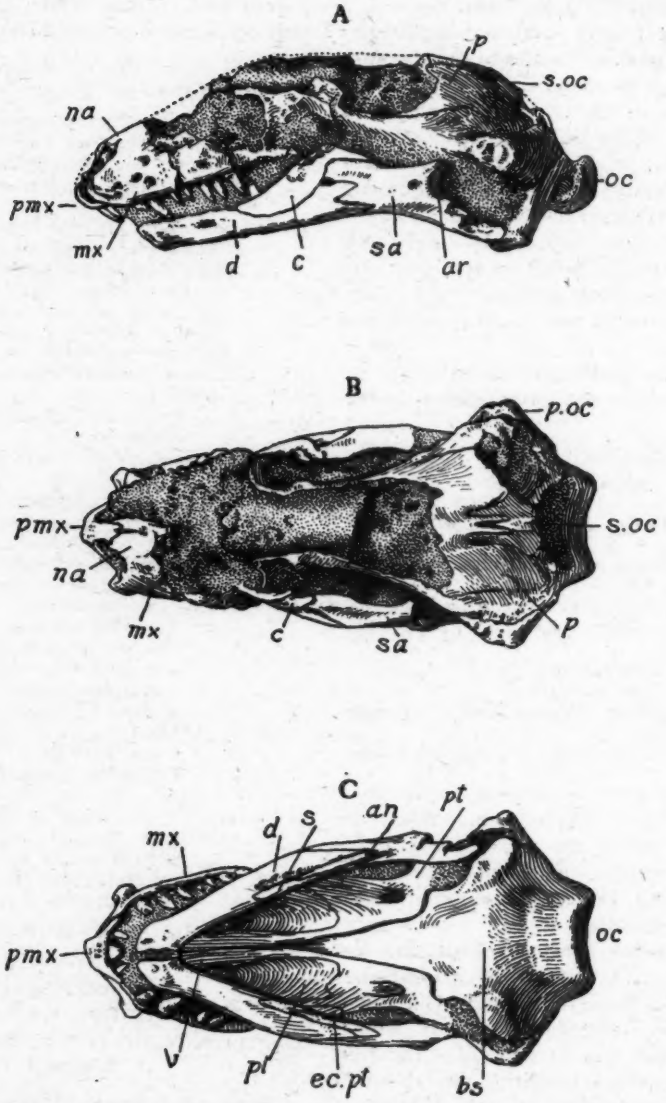

FIG. 1—Skull and lower jaws of *Ototriton minor*. Type. Princeton Museum No. 13460. A, lateral view; B, top view; C, ventral view. *An*, angular; *ar*, articular; *bs*, basisphenoid; *c*, coronoid; *d*, dentary; *ecpt*, ectopterygoid; *mx*, maxillary; *na*, nasal; *oc*, occipital condyle; *p*, parietal; *pl*, palatine; *pmx*, premaxillary; *poc*, paraoccipital; *pt*, pterygoid; *s*, splenial; *sa*, surangular; *soc*, supraoccipital; *v*, vomer. All figures 4 times natural size. Drawn by R. Bruce Horsefall.

and *Hyporhina*. Some of the known attributes which are assigned generic value are indicated in the classification key, above.

Known specimens of the two species of *Ototriton*, *minor* and *solidus*, are structurally very similar despite the great difference in size. Some distinctions and similarities may be emphasized, of course, by the imperfections of the types. Both specimens, however, represent adult individuals of approximately the same stage of individual development.

Many quite apparent structural and proportional differences of the type specimens are inordinately difficult to describe in words or by ratios of measurements. For instance it is obvious that the anterior processes (or buttresses) which extend forward from the ventral process of the basisphenoid to the pterygoid are very much longer in *O. minor* than in *O. solidus* but there are no easily indicated landmarks from which measurements can be taken to designate this difference. In fact, in every linear dimension which can be reliably measured, the type of *O. minor* is about one-half the size of *O. solidus*. Professor E. H. Taylor (personal communication) says that in the amphisbaenids such a great size difference among adults is almost certainly of specific value.

The skull of the type of the new species is a little more than half as long (17.6 mm.) as the greatest length (32 mm.) of the type of *O. solidus*, but the latter specimen is poorly preserved and is distorted in such a way that it is shortened. The maximum width of each skull in the paroccipital area is about half the greatest length (8.4 mm. for *O. minor* and 14.9 mm.[1] for *O. solidus*).

Although much of the bone in the parietal area of this new specimen is not preserved, the internal matrix cast of the superior part of the endocranial cavity suggests that the cranium was as highly arched as that of *Rhineüra hatcherii*. The remaining parietal portion of the bone shows the well-developed sagittal ridge. Anteriorly the premaxillary has the thickened truncated end which is characteristic of amphisbaenids; and its short alveolar surface supports three teeth (fig. 1c), a large median tooth (beveled by extensive wear), and on each side a smaller conical tooth. Among living amphisbaenids the African *Geocalamus* and *Agamodon* and the South American *Lepidosternon boettgeri* also have three premaxillary teeth. Loveridge (1941, p. 355) points out that the number of teeth varies in living amphisbaenidae so that the tooth count "is not quite so diagnostic of a species as was originally supposed." Extinct forms will perhaps show similar variations when series of specimens are available.

The spine of the premaxillary is short, as in *O. solidus*, and the lateral premaxillary spurs are externally overlapped by the anterior extension of the maxillaries. A considerable part of the left maxillary has been preserved. It carries seven teeth; the second from the front is the largest. Many irregularly disposed foramina perforate the maxillary bone.

Coalescence of the bones of the palate, which is nearly complete, and post-mortem fracturing make detailed interpretation of the elements uncertain. The basioccipital, basisphenoid and presphenoid bones are fully coalesced; no trace of the sutures between them is now discernible. The anterior portion of this series is plane, not keeled, between the anterior wings of the pterygoids. The thin subtriangular pterygoids are closely appressed to the overlying sphenoidal bones, with the narrowed posterior end abutting a heavy descending buttress developed on the basisphenoid as in *Rhineüra hatcherii*. Anterior to the buttress each pterygoid is penetrated by a postero-medially directed foramen.

On the outer anterior side, the pterygoid is notched for the reception of the posterior end of the ectopterygoid as shown in fig. 1c. The palatines lie along the inner side of the ectopterygoid, being separated on the posterior lateral border by the interposition of a slender tapering process of the pterygoid. The palatine appears to fill the entire palatal surface between the ectopterygoid, pterygoid, and vomer as illustrated in fig. 1c, but the difficulty of distinguishing sutures from fractures renders the extent and relationships of this element somewhat uncertain. The vomers are plane in front but become convex and separated by a fissure more posteriorly. The point of union of the vomers with the pterygoids cannot be determined

[1] A typographic error gives this dimension as 23.5 in Gilmore, 1928, p. 44.

in this specimen. Anteriorly the ends of the vomers are hidden by the attached mandibles. The saddle-shaped occipital condyle is 3.7 mm. wide.

Lower jaw.—The lower jaws are complete except for some small portions missing from the posterior end of the left ramus. They are articulated with the skull, and so closely united that irreparable damage might result if their complete separation were attempted. On that account a study of the superior border has not been possible. Many of the sutures are clearly visible, thus showing much of the detailed structure. In this specimen the following elements can be clearly identified: dentary, angular, coronoid, splenial, surangular and articular.

The angular is very small and narrow and lies mainly on the inner side of the ramus, its posterior end appearing slightly on the ventral border, where it passes diagonally across the anterior end of the surangular, (see fig. 1c), but is not visible from a lateral view (see fig. 1a).

Very short, the splenial is the usual thin splintlike element, whose spear-shaped anterior end terminates on the inside of the dentary at midlength of that bone. The inferior posterior border of the splenial articulates with the angular and the posterior end appears to meet the surangular. There is no indication of Meckel's groove. Although its superior process is broken, the coronoid is obviously large, and extends far down on the external side of the dentary, as shown in fig. 1a. Its internal relationships cannot be determined from this specimen.

The posterior external portion of the ramus back of the coronoid is to a great extent composed of the surangular and articular bones. These elements are so fully coalesced that no trace of their union can now be detected. It is presumed that all of the bone between the cotylus and the coronoid as viewed laterally is surangular. Its contact with the dentary is Z-shaped. About one-half of its anterior upper border supports the posterior wing of the coronoid. The lower border is successively underlapped by sharply pointed processes from the dentary and the angular. As in *Rhineüra* the cotylus for the quadrate is deep. The articular portion of the ramus behind the cotylus is narrow vertically and terminates in a blunt end in front of the basipterygoid process. In this extension of the ramus behind the cotylus the mandible resembles those of *Rhineüra* and *Hyporhina* and is quite unlike the rami of the modern *Agamodon*, *Monopelitis* and *Amphisbaena* which have no such extension.

The greatest length of the mandible is 13.2 mm.

MANUSCRIPT RECEIVED MARCH 8, 1944.

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THE BIOSTRATIGRAPHY OF GLYCYMERIS VEATCHII IN CALIFORNIA[1]

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ABSTRACT—The stratigraphy and correlation of Upper Cretaceous rocks comprise one of the important problems of Pacific Coast geology, particularly as the search for petroleum extends to progressively older rock formations in California. This paper assists in the solution of the problem by tracing the variation and evolution of a single fossil molluscan species, *Glycymeris veatchii*, during Upper Cretaceous and early Tertiary time.

Results of the present study are as follows: (1) the evolution of *Glycymeris veatchii* can be definitely traced; (2) the number of ribs on a valve in this molluscan group varies inversely with the geologic age of the specimen; and (3) two new varieties, *Glycymeris veatchii reddingensis*, and *G. veatchii anae*, and one new species, *G. meganosensis*, are recognized. The species *G. major* is shown to be invalid.

A tentative correlation of the localities where *Glycymeris* is found in the Upper Cretaceous is presented. Systematic descriptions of species and varieties are included.

INTRODUCTION

THE STRATIGRAPHY and correlation of Upper Cretaceous rocks comprise one of the major problems of Pacific Coast geology. Information bearing on this subject is rapidly assuming added economic significance as the search for petroleum penetrates into progressively older rock formations in California. Although general relationships of the various Cretaceous strata are well known, little has been done with detailed subdivision into series, stages, and zones, so essential to economic exploitation. As an aid to a better understanding of the sequence and correlation of the stratigraphic units that are grouped in the late Cretaceous and early Tertiary, the present paper attempts to indicate the variation and evolution in a single fossil molluscan species during this portion of geologic time.

This study is primarily paleontologic, one of its purposes being to determine the time-stratigraphic positions of the varieties of *Glycymeris veatchii* that have been listed, described, or figured since Gabb's original work. Large collections were examined from widely separated localities in California, representing the few established horizons in the Upper Cretaceous section. The evolutionary trends of *Glycymeris veatchii* indicated by this study were traced with the use of additional collections, until nearly all well-exposed Upper Cretaceous sections that yield fossil specimens in the State had been assigned positions in the stratigraphic column.

Stratigraphic subdivision or correlations established on the basis of a single species should be modified by a consideration of the trends within the faunas as a whole. The evolution of any individual or group of related individuals, while paralleling the evolution of the entire fauna, may be accelerated or retarded with respect to the rate at which the assemblage as a whole evolves. For this reason the tentative correlation chart (table 1) combines the results of this paper and unpublished work by Dr. W. P. Popenoe.

I am indebted to Dr. Willis P. Popenoe of the California Institute of Technology for suggesting the problem and for counsel and advice throughout the period of its investigation. In addition, Dr. Popenoe has furnished a large portion of the stratigraphic data and has generously made available much unpublished material. Dr. Chester Stock criticized the manuscript and gave generously of his time during its preparation. I am indebted to George P. Zebal for unpublished information on the stratigraphy of the Simi Hills.

STATEMENT OF PROBLEM

Glycymeris veatchii is an abundant pelecypod in most of the fossiliferous Upper

[1] BALCH GRADUATE SCHOOL OF THE GEOLOGICAL SCIENCES, CALIFORNIA INSTITUTE OF TECHNOLOGY, PASADENA 4, CALIFORNIA. CONTRIBUTION NO. 364.

Cretaceous deposits of the Pacific Coast. Similar forms, some described as variants, others as new species, are found in the Martinez Paleocene and in the Meganos of the Eocene. The problem presented by these molluscs may be stated as follows: Do the several forms referred to *Glycymeris veatchii* in the Cretaceous and Eocene comprise a genetic line? If evolutionary trends exist, are the forms to be related to one restricted species, several varieties of a species, or to several new species? Finally, to what extent can evolutionary trends and variations be related to stratigraphy?

METHOD OF INVESTIGATION

In the present study more than 2000 specimens were examined, of which over 750 were measured. These pelecypods had been identified as *Glycymeris veatchii*, *G. veatchii major* Stanton, *G. major* Stanton, and *G. major meganosensis* Clark. Measurements were made of the thickness, length, and height of the shell, as well as of the widths of the ribs and of the rib interspaces. In addition, the number of ribs was counted, character and amount of concentric sculpturing on each valve were observed, degree of development of posterior groove noted, and the position of the beaks established where this was possible. Ratios of length to thickness, height to thickness, and height to length were calculated in order to reduce these data to certain common denominators by which comparisons might be more readily comprehended. In this way, variations which are magnified by the size of the animal come to be seen in proper perspective, while evolutionary trends are more clearly indicated. Also, local variations due to possible environmental influences rather than evolution are thus more readily recognized. All specimens less than 6 mm. in thickness were considered immature and their proportions were calculated separately. This separation was made (1) because it became evident early in the investigation that a thickness or convexity of shell of about 6 mm. marks a rather sharp break within the growth series; all specimens of less thickness tend to have much higher ratios of length to thickness and height to thickness than do larger more convex specimens; and (2) measurements of valves less than 6 mm. in thickness are subject to considerable error, in some cases sufficient to invalidate the results obtained from such measurements.

The stratigraphic succession of the localities from which individual specimens were measured was determined by reducing individual shell ratios to average values for a single locality. Localities representing the same time stages or narrow time-stratigraphic zones were combined by weighing the average ratios with the number of specimens measured from each locality. Where satisfactory stratigraphic information is available this procedure is simple, but in instances where the stratigraphy is little known or unknown altogether, the relative age of the locality is based on the apparent evolutionary stage of the individual specimens. This obviously does not furnish the most accurate results but appears to be the only method available to the investigator under the circumstances.

EVOLUTIONARY TRENDS AND VARIANTS

The results of the present study are threefold: (1) the evolution of *Glycymeris veatchii* is found to continue in an unbroken line throughout the time range of the species from lower Upper Cretaceous rocks in the vicinity of Redding to Martinez rocks, near Lower Lake, California. (2) The number of ribs on a valve is found to vary inversely with the geologic age of the specimen. (3) *Glycymeris veatchii, sensu stricto*, has a much more restricted range than heretofore determined. Particular variants may be recognized at nearly every Upper Cretaceous locality other than those correlated with the type locality. The variants are listed as follows: *G. veatchii reddingensis*, *G. veatchii anae* and *G. veatchii major*. A description of each of these and a detailed account of *G. veatchii, sensu stricto*, will be found in the systematic catalogue in the latter part of the paper.

Glycymeris major Stanton is apparently not a valid species. However, the form may show sufficient distinctiveness from the type *Glycymeris veatchii* to warrant its recognition as a separate variety.

Glycymeris major meganosensis Clark and Woodford, 1927, is thought to show features that digress markedly from the evolutionary

trends shown by *G. veatchii* and is therefore raised to the rank of species.

STRATIGRAPHY

Variations of *Glycymeris veatchii, sensu lato*, were determined by measurements of specimens from 22 localities in the Redding district, 24 in the Santa Ana Mountains, 6 in the Simi Hills, 6 in the Santa Monica Mountains, 4 in the Chico Creek section, 8 in the Los Banos region, 2 in the "Martinez" of the Simi Hills, 1 at Lower Lake, and 1 in the type Meganos formation, all in California. A brief description of the stratigraphy at some of these places follows:

Redding district.—Popenoe (1943, pp. 306–312) has recently published a short description of the stratigraphy of the Redding district in which he divides the Cretaceous rocks into six members. In the present investigation attention is directed to the upper members, since *Glycymeris veatchii reddingensis* has not been found stratigraphically below member IV. Member V is divided into an upper and a lower part. While there is no stratigraphic basis for this division except an abundance of coarse conglomerate in the lower half, the division is recognized because of a recognizable modification in the evolutionary trends of *G. veatchii reddingensis.*

Chico Creek section.—Taff, Hanna, and Cross (1940, pp. 1311–1315) have described the type section of the Chico formation on Chico Creek in some detail. They found no basis for a division into an upper and lower Chico, although such a division is made in this paper. This division is recognized here in order to indicate possible evolutionary progress in *G. veatchii* during deposition.

Santa Ana Mountains.—The occurrences of *Glycymeris veatchii* in the Santa Ana Mountains are grouped in three zones. The third zone overlies the lower two with disconformity as indicated by Popenoe (1942, pp. 162–187) in a recent publication which summarizes the geology of the Santa Ana Mountains.

The lowermost occurrence of *G. veatchii* in the Santa Ana Mountains is in the upper half of the Holz member of the Ladd formation. The upper half of the Holz shale is highly fossiliferous and includes two faunal zones. There is but slight lithologic evidence for this separation, but the fauna shows a distinct break. The lower zone ranges from midway in the section to approximately 200 feet below the top of the shale; the middle zone comprises the upper 200 feet.

The upper zone in the Santa Ana Mountains is found in the Williams formation. The only fossils found in this formation are confined to the upper member, the Pleasants sandstone; *Glycymeris veatchii anae* is abundant in all collections from this formation, but many of the forms are poorly preserved.

Penz Ranch.—The section at Penz Ranch on the eastern side of the Sacramento Valley, south of Chico Creek, is not very well exposed. The rocks are primarily sandstones and conglomerates similar to those exposed on Chico Creek.

Tuscan Springs.—Tuscan Springs, the type locality for *Glycymeris veatchii*, is on Little Salt Creek about 8 miles northeast of Red Bluff, California. The rocks at Tuscan Springs are a northward continuation of those exposed on Chico Creek. They are for the most part pebbly or silty sandstones and conglomerates.

Santa Monica Mountains.—The Upper Cretaceous rocks comprise about 8000 feet of conglomerate, arkose, and sandstone. They have been mapped by Hoots (1930) and Wilson (MS). The only fossiliferous horizon is a well-bedded, fine-grained sandstone 300 feet thick and approximately 1000 feet below the top of the section. An interesting feature of *Glycymeris veatchii* found here is the large size attained by the specimens; some exceed 70 mm. in height and length.

Simi Hills.—Zebal (MS) who has revised the geology of the Upper Cretaceous exposures in the Simi Hills, by detailed mapping has shown that the several fossil localities which furnish the collections belong to the same bed, contrary to the suggestion of Popenoe (1942, p. 186). The evolutionary characters developed by *Glycymeris veatchii anae* substantiate Zebal's detailed mapping.

"Quinto B" reef bed.—The "Quinto B" reef bed (Bennison, MS) is exposed on Los Banos Creek, west of Los Banos, California, and contains almost exclusively *Glycymeris veatchii major*. The rocks are sandstones and sandy shales with some conglomerate outcropping in thick sections in Los Banos

Creek, Garzas Creek, Moreno Gulch, and along other streams that flow into the San Joaquin valley. Most of the fossils come from the upper 2500 feet of the section. Shells of the variant *G. v. major* usually exceed 20 mm. in height and average between 40 and 45 mm. in height.

Type Garzas.—The type Garzas section is in all respects similar to those on Los Banos Creek or in Moreno Gulch. The youngest Upper Cretaceous specimens available for measurement were contained in this section from Garzas Creek, northwest of Los Banos, California.

"Martinez" of the Simi Valley.—The Simi Valley "Martinez" has been described by Kew (1919, pp. 323–347) and Nelson (1925, pp. 399–402). The rocks are dominantly shales with a little sandstone and a basal conglomerate. All the fossils come from the marine member of the formation.

Lower Lake, California.—Dickerson (1914, pp. 89–99) described the Martinez rocks near Lower Lake, California, as comprising from 3000 to 3500 feet of sandstone underlain by 300 to 500 feet of shale. The principal fossiliferous horizon lies approximately 100 feet above the base of the formation.

Type Meganos.—The type Meganos is described by Clark and Woodford (1927, pp. 63–142) as comprising about 1000 feet of sandstone with a heavy basal conglomerate and narrow shale layers near the top. Overlying the sandstones are alternating sandstones and shales approximately 2000 feet thick; the fossiliferous horizon occurs in calcareous lenses approximately 1500 feet below the top of the formation.

CORRELATION

The stratigraphic sequence of the Upper Cretaceous and lower Eocene strata as suggested by the variations of *Glycymeris veatchii, sensu lato,* is as follows:

Sequence of strata indicated by the evolution of Glycymeris veatchii

Lower Eocene:
- Meganos of Mount Diablo quadrangle (type locality).
- Martinez at Lower Lake.
- Marine member of the Martinez at Simi Valley.

Unconformity.

Upper Cretaceous:
- Garzas at Los Banos (type locality).
- Los Banos Creek member of "Quinto B" reef beds at Los Banos.
- Pleasants sandstone member of Williams in Santa Ana Mountains.
- "Upper Chico" at Simi Hills.
- "Chico-Martinez" in Santa Monica Mountains.
- "Chico" at Tuscan Springs.
- "Chico" at Penz ranch.
- Upper and lower parts of Holz shale member of Ladd in Santa Ana Mountains.
- Upper and lower members of type Chico at Chico Creek.
- Member VI of "Lower Chico" at Redding.
- Upper and lower parts of member V of "lower Chico" at Redding.
- Member IV of "lower Chico" at Redding.

The correlation chart, table 1, which is based on unpublished work by Dr. W. P. Popenoe and on the studies presented in this paper, shows the tentative stratigraphic relations of the deposits in different parts of California.

The rocks of the first three members of the Redding district probably represent some of the oldest Upper Cretaceous formations on the Pacific Coast. It is possible that the fossiliferous zones below Popenoe's (1942, p. 183) *Glycymeris veatchii* zone in the Santa Ana Mountains correlate with these beds.

Glycymeris veatchii reddingensis first appears in member IV of the Redding section. In specimens from this area the number of ribs averages less than 32, the valves are slightly longer than high, and they are not particularly inflated as compared with those of *G. veatchii, sensu stricto,* from Tuscan Springs. A curious anomaly appears in forms found higher in the section. Although throughout the entire range of Upper Cretaceous time the average number of ribs increases as one proceeds toward the top of the deposits, in shells found locally in the Redding section the number of ribs decreases slightly from bottom to top of the stratigraphic section. No explanation is offered for this peculiarity, although it may be noted that the decrease is slight and not uniform through the section.

TABLE 1. TENTATIVE CORRELATION OF LATE CRETACEOUS AND EOCENE DEPOSITS

Age	Southern California	West side Great Valley	East side Sacramento Valley	Redding district
EOCENE	"Martinez" at Simi Valley	Type Meganos		
		"Martinez" at Lower Lake		
UPPER CRETACEOUS		Type Garzas "Quinto B" Reef Beds		
	Upper zone, Santa Ana Mts., Simi Hills			
	Santa Monica Mts.			
	Middle zone, Santa Ana Mts.		Tuscan Springs and Penz ranch	
	Lower zone, Santa Ana Mts.			
			Type Chico	Member VI Member V
				Member IV

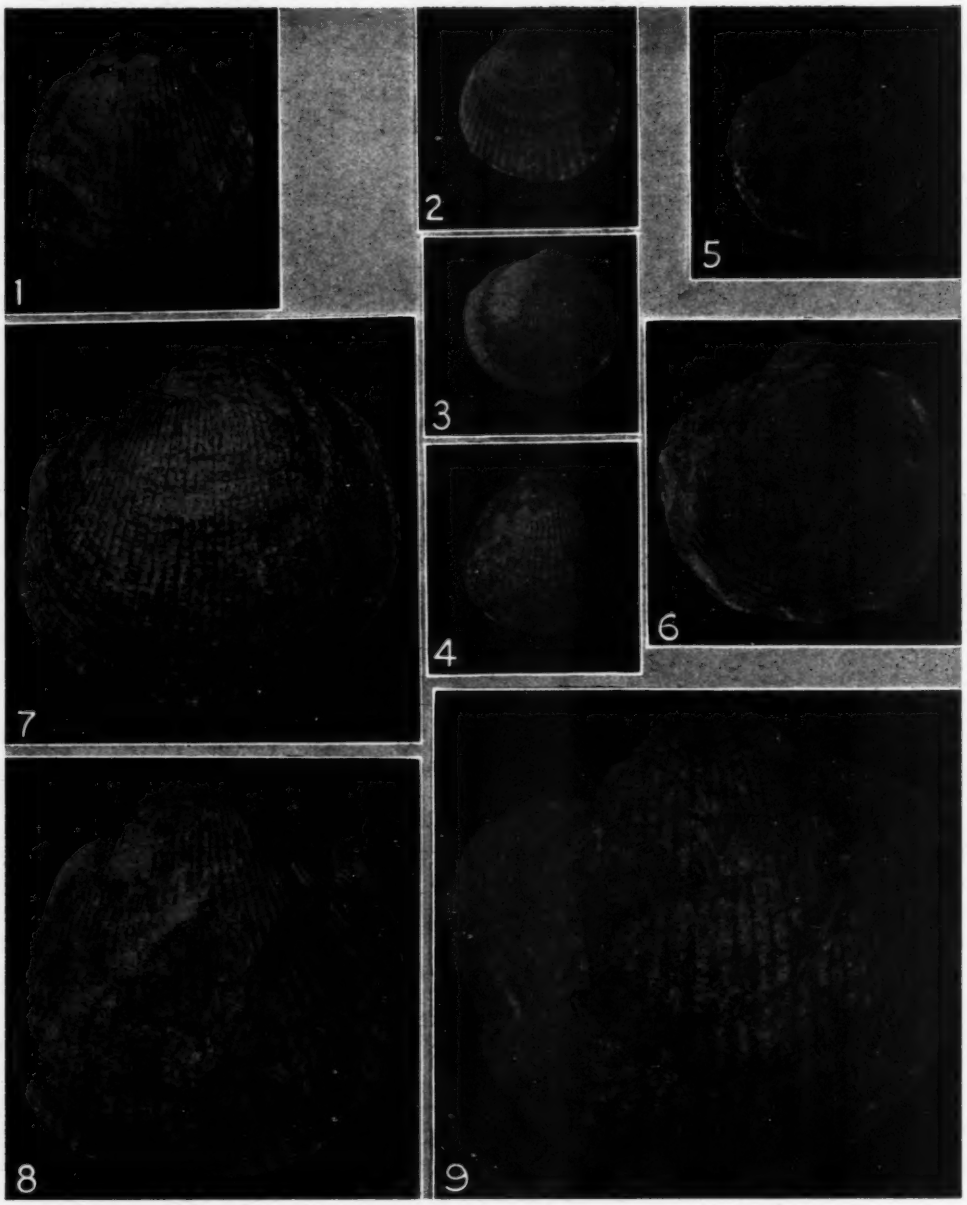
Popenoe (1941, p. 2095) has suggested that member V of the Redding section may be correlated with the base of the type Chico on Chico creek; *Glycymeris veatchii reddingensis* from member IV at Redding may represent the same evolutionary stage as *G. veatchii reddingensis* found in the lower parts of the type Chico at Chico creek. *G. veatchii reddingensis* from the "upper Chico" at Chico Creek appears to be younger than any of the forms found in the Redding section.

The lowermost zone containing *G. veatchii anae* in the Santa Ana Mountains appears to be slightly younger than any horizon examined on Chico Creek or at Redding. Furthermore, both the lower and middle zones in the Upper Cretaceous of the Santa Ana Mountains appear to be slightly older than the occurrence at Penz ranch and at the type locality of Tuscan Springs. In contrast to the specimens from the type locality, those from the Santa Ana Mountains are considerably longer than they are high and show a marked reduction in convexity. These features seem to be confined to forms from the Santa Ana Mountains but are exhibited to a lesser degree by specimens from the Simi Hills. The Eocene specimens show a similar but less marked variation.

The specimens from the Penz ranch show such slight differences from those from the type locality at Tuscan Springs that they are regarded as of the same or nearly equivalent age.

The fossiliferous horizon in the Upper Cretaceous of the Santa Monica Mountains appears to be slightly older than the upper zone of the Santa Ana Mountains and the fauna from the Simi Hills. The differences are so slight that all are relegated to the same time stage and are considered slightly younger than the faunas from Tuscan Springs and Penz ranch.

The youngest Cretaceous forms of *G. veatchii* that were measured come from the "Quinto B" reef beds and from the type Garzas beds on the west side of the San



EXPLANATION OF FIGURES 1–9

FIGS. *1, 9—Glycymeris veatchii* (Gabb). *1*, Typical form from type locality, Tuscan Springs, Calif. *9*, Giant form from the Santa Monica Mountains. (p. 41)

2, 4—Glycymeris veatchii reddingensis Smith, n. var. Syntypes, C.I.T. loc. 1233, near Redding, Calif. (p. 42)

3, 7—Glycymeris veatchii anae Smith, n. var. *3*, Syntype, C.I.T. loc. 974, Santa Ana Mountains. *7*, Large form common in the Santa Ana Mountains. (p. 42)

5, 8—Glycymeris veatchii major (Stanton). *5*, Typical form from the Martinez of the Simi Valley, Calif. *8*, Typical form from the type Garzas formation, Garzas Creek, Calif. (p. 42)

6—Glycymeris meganosensis Clark and Woodford. Typical form from the type locality of the Meganos formation, Mount Diablo quadrangle, Calif. (p. 43)

Joaquin Valley, west and north of Los Banos, California. In contrast to the earliest forms from member IV at Redding, these specimens average more than 40 ribs and are slightly less inflated. At any one locality shells may be found that can be assigned to either the top or bottom of the evolutionary sequence on the basis of their characters. Greater assurance of the time allocation of such materials is furnished when the structural characteristics of the average of 20 or more specimens from a single locality are analyzed.

The small number of specimens available from the Eocene localities permits only recognition of a continuation of evolutionary trends in post-Cretaceous time.

CONCLUSION

Where the stratigraphic succession has been completely established over a considerable period of geologic time, evolutionary trends in *Glycymeris veatchii* are indicated. These trends appear to be valid for the entire range of occurrences of *G. veatchii*, at least on the evidence of the limited knowledge available concerning the Upper Cretaceous stratigraphy of the Pacific Coast. Indeed, the suggestion of stratigraphic position made in the present paper may assist in throwing needed light on obscure correlations.

Detailed correlations on the basis of a single species have not been attempted for reasons stated previously, but it is noteworthy that previously suggested correlations, for which there is some evidence, appear to be substantiated by this study.

SYSTEMATIC DESCRIPTIONS

Class PELECYPODA

Genus GLYCYMERIS da Costa

GLYCYMERIS VEATCHII (Gabb)

Figures 1, 9

Axinaea veatchii GABB, 1864, Paleontology of California, vol. 1, p. 197, pl. 25, figs. 183, 183a.

Pectunculus veatchii (Gabb) STANTON, 1896, U. S. Geol. Survey 17th Annual Report, pt. 1, p. 1039, pl. 64, fig. 1.

Pectunculus veatchii (Gabb) WHITEAVES, 1900, Canada Geol. Survey Mesozoic Fossils, vol. 1, p. 391, pl. 47, figs. 3, 4.

Pectunculus veatchii (Gabb) ANDERSON, 1902, California Acad. Sci. Proc., ser. 3, vol. 2, no. 1, p. 35.

Glycimeris veatchii (Gabb) WARING, 1917, California Acad. Sci. Proc., ser. 4, vol. 7, no. 4, p. 61, pl. 8, figs. 2, 7, 8.

Glycymeris veatchii (Gabb) STEWART, 1930, Acad. Nat. Sci. Philadelphia Spec. Publ. 3, p. 70, text fig. 1, pl. 1, fig. 7.

Measurements of 12 perfectly preserved specimens of *Glycymeris veatchii* from the type locality show that the valves are either longer than high or higher than long, the average of all shells being equilateral. The number of ribs varies from 35 to 42, averaging slightly less than 38. The ribs are from 0.2 to 0.6 mm. wider than the interspaces and somewhat variable in size anteriorly and posteriorly. Umbo either prosogyral or opisthogyral; posterior depression well marked; ventral margin of shell slightly crenulate from concentric growth sculpturing. Average specimen 30.6 mm. high, 30.8 mm. long, and 13.7 mm. thick.

Discussion.—Measurements of specimens from all localities are summarized in table 2 in the form of averages and ratios. In preparing this table it was noted that the range in size of the shells is reflected by the average widths of the ribs and interspaces. Average rib widths in excess of 1.0 mm. are found in valves with lengths and heights in excess of 30 mm.; average rib widths between 0.8 mm. and 1.0 mm. are characteristic of valves with lengths and heights between 20 mm. and 30 mm.; average rib widths of less than 0.8 mm. are found in valves with heights and lengths of less than 20 mm. In determining the degree of convexity reference should be made to the ratio of length to thickness or height to thickness.

The largest valves measured in the entire series come from the Santa Monica mountains and from one locality in the Santa Ana mountains. These specimens measured approximately 75 mm. in length, more than 70 mm. in height and more than 30 mm. in thickness. A few large valves were found at almost every locality, regardless of its stratigraphic position.

The smaller valves were subdivided into immature and mature specimens, the basis of the division being a 6 mm. thickness of the valve. Valves thinner than 6 mm. show uniformly very high ratios of length and height to thickness as compared to valves with thicknesses of 6.5 mm. to 7 mm. or more. The division at 6 mm. is of course arbitrary, but it was found that few specimens

having smaller values could be measured with those standards of accuracy that were applied to adult specimens. Statistical information regarding the immature valves is given in table 3.

In what follows the descriptions of variants are based on forms exceeding 6 mm. in thickness.

GLYCYMERIS VEATCHII REDDINGENSIS Smith, n. var.

Figures 2, 4

Compared with the typical form of the species this variety is smaller. The valve possesses, on the average, less than 33 ribs. Individual specimens may be indistinguishable from those of the typical form when the number of ribs is greater than 36, but valves with that number of ribs are rarely found where this variety occurs. A typical specimen measures 18.3 mm. in length, 19.2 mm. in height, and 7.5 mm. in thickness. In this valve 30 ribs are present.

Syntypes.—C.I.T. Invertebrate Paleontology cat. no. 4741, loc. no. 1233.

GLYCYMERIS VEATCHII ANAE Smith, n. var.

Figures 3, 7

Compared with the typical form this variety may have either more or fewer ribs, the number ranging from 33 to 45 or more. The chief distinguishing feature is the proportionally longer valve. Where the typical form of the species is very nearly equilateral, the new variety has a ratio of height to length that averages less than 0.95 and may be as low as 0.80. This proportion yields a characteristic shape even in valves that are badly damaged or deformed. An average specimen measures 20.2 mm. long, 18.8 mm. high, and 7.9 mm. thick.

Syntypes.—C.I.T. Invertebrate Paleontology cat. no. 4742, loc. no. 974.

GLYCYMERIS VEATCHII MAJOR (Stanton)

Figures 5, 8

Pectunculus veatchii var. *major* Stanton, 1896, U. S. Geol. Survey 17th Ann. Rept., p. 1, p. 1040, pl. 64, figs. 2, 3.

Measurements on a large number of specimens from the "Quinto B" reef bed and the

TABLE 2. AVERAGE MEASUREMENTS AND RATIOS OF VARIETIES OF GLYCYMERIS VEATCHII, SENSU LATO

Locality	Quantity	Number of ribs	Width of rib (mm.)	Width of interspaces (mm.)	H/L	L/T	H/T
Type Meganos	10	37.00	0.950	0.300	0.94	2.57	2.42
Lower Lake, "Martinez"	1	45.00	1.700	1.100	0.92	2.17	1.99
Simi Valley, "Martinez"	12	40.14	0.940	0.480	0.94	2.55	2.40
Garzas Creek, type Garzas	15	40.64	1.583	1.625	0.98	2.54	2.51
Los Banos Creek, "Quinto B" reef beds	117	40.18	1.139	1.179	0.99	2.57	2.50
Santa Ana Mountains, upper zone	66	39.67	0.610	0.506	0.92	2.46	2.27
Simi Hills	58	39.48	0.605	0.560	0.95	2.42	2.28
Santa Monica Mountains	29	38.72	1.309	1.082	0.98	2.38	2.31
Tuscan Springs	12	37.92	1.092	0.858	1.00	2.23	2.21
Penz Ranch region	24	36.74	1.145	0.968	0.99	0.26	2.22
Santa Ana Mountains:							
Middle zone	113	35.79	0.597	0.495	0.92	2.51	2.33
Lower zone	69	34.48	0.510	0.500	0.94	2.63	2.41
Chico Creek region:							
Upper zone	4	33.50	0.850	0.750	0.98	2.25	2.10
Lower zone	32	31.83	0.686	0.529	0.99	2.32	2.29
Redding district							
Member VI	9	29.83	0.725	0.450	0.97	2.35	2.27
Member V:							
Upper half	189	29.31	0.695	0.484	1.01	2.19	2.21
Lower half	61	30.43	0.655	0.389	0.99	2.16	2.14
Member IV	41	32.00	0.809	0.463	1.02	2.18	2.21

TABLE 3. AVERAGE MEASUREMENTS AND RATIOS OF IMMATURE SPECIMENS OF GLYCYMERIS VEATCHII[1]

Locality	Quantity	Number of ribs	Width of rib (mm.)	Width of interspaces (mm.)	H/L	L/T	H/T
Santa Ana Mountains							
Upper zone	37	39.16	0.425	0.400	0.88	3.22	2.84
Simi Hills	31	36.45	0.420	0.380	0.90	2.83	2.54
Penz ranch region	22	38.00	0.400	0.350	0.89	2.91	2.57
Santa Ana Mountains							
Middle zone	69	32.96	0.413	0.347	0.90	2.75	2.46
Lower zone	19	33.11	0.300	0.300	0.91	2.86	2.61
Chico Creek, Lower zone	1	33.00	—	—	0.99	3.14	3.12
Redding district							
Member VI	1	—	—	—	0.92	2.34	2.16
Member V:							
Upper half	31	32.17	0.425	0.325	0.96	2.93	2.80
Lower half	39	41.00	0.500	0.200	0.97	2.68	2.58
Member IV	3	37.50	—	—	0.95	2.94	2.82

[1] No immature specimens found in collections from Type Meganos, Lower Lake "Martinez," Simi Valley "Martinez," Garzas Creek Type Garzas, Los Banos Creek "Quinto B" Reef Beds, Santa Monica Mts., Tuscan Springs, Chico Creek upper zone.

type Garzas formation indicate that this variety, compared with the typical form of the species, has on the average two or three more ribs; the ribs are usually wider than the interspaces, although the reverse may occur; the shell is considerably larger and slightly less convex. A typical specimen measures 46.5 mm. in length, 46 mm. in height and 18.6 mm. in thickness. This valve has 42 ribs.

Discussion.—The variety is difficult to distinguish from typical *G. veatchii*, unless large numbers of specimens are available for study. Measurements of individual shells indicate that the ribs are commonly wider than the interspaces in all the varieties of *G. veatchii*. Large and small forms occur together, making size of little value in the determination of a distinct variety. However, when more than 20 specimens are considered, the additional ribs, the larger average size, and the reduced convexity are thought to establish the validity of this variety.

Nelson (1925, p. 402) in a description of the Simi Valley "Martinez" marine rocks lists the name *Glycymeris major* as one of the fossil pelecypods found in these deposits. Nelson apparently intended to recognize the variety *major* as a distinct species, but the results of this study indicate that *Glycymeris major* is merely a variety.

GLYCYMERIS MEGANOSENSIS
Clark and Woodford

Figure 6

Glycymeris major meganosensis Clark and Woodford, 1927, California Univ. Dept. Geol. Sci. Bull., vol. 17, no. 2, p. 86, pl. 14, figs. 4, 5.

Measurements of a limited number of specimens show that the ribs average more than 0.6 mm. wider than the interspaces, and the difference is often considerably greater than this. In most specimens of typical *Glycymeris veatchii* the ribs are not more than 0.4 mm. to 0.6 mm. wider than the interspaces. In *G. meganosensis* the number of ribs averages less than 35. Thus, the distinction between the typical form and the new species is quite marked.

Discussion.—The number of specimens available is insufficient to demonstrate adequately the amount or degree of obsolescence of the ribs. On 10 specimens measured the rib counts were considerably higher than 30, the number given by Clark and Woodford (1927). However, the number or ribs is far less than that which would be expected from a consideration of the evolutionary trends shown by shells from older horizons. Obsolescence of the ribs on the ventral edge, due to concentric lines of growth, was not observed.

Since the ribs indicate the evolution of *G. veatchii* more clearly than any other single characteristic of the shell, the abrupt reduction in rib count is taken to indicate the substitution of other evolutionary characteristics for those which controlled the evolution prior to Meganos time. Markedly narrower interspaces, in some cases so narrow as to appear merely as lines on the shell, as well as a reduction in number of ribs below that which might be expected in specimens so far along the evolutionary scale, furnish a satisfactory basis for recognition of this so-called subspecies as a species.

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THE CRETACEOUS FLORA FROM THE PANTOU SERIES IN YUNGAN, FUKIEN

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INTRODUCTION

THE SMALL FLORULE described in the following pages was collected by Mr. C. S. Kao and the writer in the winter of 1942. The plant-bearing strata are exposed near the city of Yungan. Mr. M. K. Chern named these beds the Pantou series. It consists mainly of white, gray and brownish shales and sandstones up to 900 m. in thickness. It is overlain by the "red-beds" mostly of sandstones and rests on a volcanic lava flow known as "red rhyolite." In addition to the plant fossils, several imperfectly preserved fish remains, probably of the *Lycoptera* group have also been found. The small phyllopod shells *Estheria* seem to be the most abundant fossil in the material. These beds, according to Chern, probably belong to the Upper Cretaceous or a lower horizon, the Middle Cretaceous. Plant remains however clearly show that this series must be of Lower Cretaceous age. The reason will be given below.

The original specimens are preserved in the Institute of Geology, Academia Sinica. The figures were drawn under the Parkes-Lapworth microscope by the writer.

DESCRIPTION OF SPECIES

SPHENOPTERIS sp. (cf. RUFFORDIA GÖPPERTI Dunker)

Figure 16

The small fragment of a sphenopteroid form shown in fig. 16 is too imperfectly preserved for accurate determination, but seems to represent a very characteristic type. It consists of a small part of a pinna showing the characteristic delicate pinnules more or less decurrent on the rachis, with the broad somewhat obtusely rounded segments. In each lobe of the pinnae are several palmately placed veins. This form agrees fairly well with *Ruffordia göpperti* (Dunker) Seward, especially with the specimen figured by Seward in his Fossil Plants of the Wealden pt. 2, pl. 5, fig. 4. It agrees also closely with the Japanese examples figured by Nathorst (1890, pt. 2, pl. 6, figs. 2, 3) as *Sphenopteris* cf. *s. göpperti*. Most of the specimens of the English Wealden are characterized by their much narrower segments, but when a careful survey is made of a large number of specimens, intermediate forms arrange themselves between the narrow- and broad-leaved types. The general habit is practically identical in the two extreme forms, and Seward says for instance (1894, p. 82):

> The first glance at this specimen and fig. 2 of the same plate suggests two specific forms, but on close inspection, of the two specimens, a difference in breadth of the ultimate divisions appears to be the only real distinction and, in view of the correspondence in habit, this alone is hardly of sufficient importance to necessitate a separate species.

According to Seward, in addition to the specimens figured by Nathorst from Japan as *Sph. göpperti*, those fragments described and figured by Yokoyama as *Thyrsopteris kagensis* Yokoyama should also be compared with the present species; there is no adequate reason for referring them to the genus *Thyrsopteris*. The generic name *Ruffordia* was proposed by Seward for the specimens of the Wealden formation in Northern Germany originally described by Dunker as *Sphenopteris göpperti*. The genus is thus defined

> Frond tripinnate-quadripinnate, deltoid or rhomboidal, rachis frequently flexuous, pinnae alternate, deltoid to ovate-lanceolate; pinnules delicate, decurrent on the rachis, ultimate segments linear, acuminate or ovate-cuneate. Venation of the type *Caenopteridis* and *Sphenopteridis*. Fructification in the form of scattered sporangia on fertile fronds or pinnae of which the leaf lamina is considerably reduced (Seward, 1894, pt. 1, p. 77).

The genus *Ruffordia* is thus characterized by a distinct contrast between sterile and fertile specimens. The fertile specimens figured by Seward (1894, pl. 5, fig. 5) are hitherto unknown in the Japanese Wealden. During

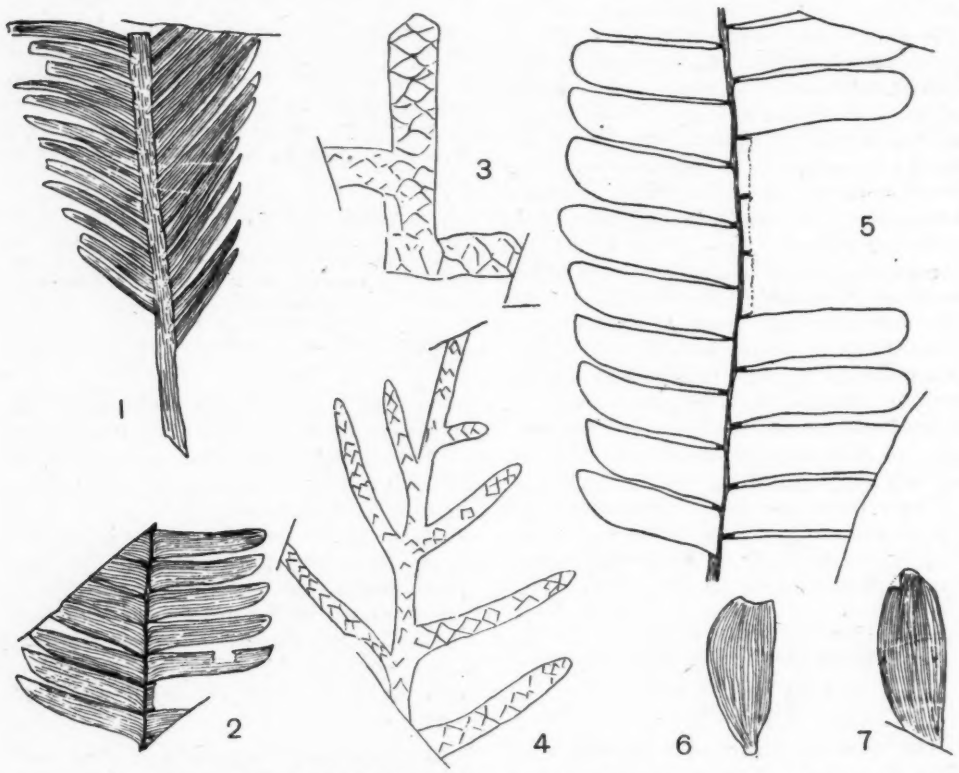
the field investigation, the writer has paid much attention to searching for such specimens in the present locality but in vain. According to Seward the fertile pinnae of *Ruffordia göpperti* suggest a connection with *Anemia*, and the character of the sterile fronds is strongly confirmatory. The sterile and fertile pinnules are closely comparable to *Anemia adiantifolia* Seward. On the other hand, no details can be made out in the sporangia which would afford the most trustworthy kind of evidence in favor or against a reference to the *Schizaeaceae* and as Gothan says in his Lehrbuch, p. 55:

Von Seward werden auch die als *Ruffordia göpperti* Dunk. sp. bezeichneten *Sphenopteris*-Reste des Weald, allerdings mit Reserve auf Grund äusserer Ähnlichkeiten mit Aneimien hierher gebracht.

On account of the fragmentary preservation of the specimen and the absence of the characteristic fertile pinnules, the writer assigns the present form to *Sphenopteris* sp. (cf. *Ruffordia göpperti* Dunker).

ONICHIOPSIS? sp.
Figures 11, 12

The specimens under this genus are too fragmentary and too badly preserved to be determined. So far as the writer has been able to compare, it is impossible to include these fossils in any known genus. The small, narrow, lanceolate, acute pinnules seem to be most nearly comparable to those of *Onychiopsis*, but on account of the absence of the characteristic longer, larger serrate pinnules and the characteristic fertile exam-



FIGS. *1*, *2*—*Ptilophyllum boreale* (Heer) Seward. *1*, Impression of the lower surface of the leaf; *2*, impression of the upper surface of the leaf; ×1.3. (p. 49)
3, *4*—*Brachyphyllum obesum* Heer, ×1.3. (p. 50)
5—*Nilssonia* sp. (n. sp.). Impression of the upper surface of the leaf, showing the bases of the segments meeting almost in the middle of the rachis; ×1.3. (p. 50)
6, *7*—*Podozamites?* sp., ×1.3. (p. 52)

ples in the material, it seems premature to identify the specimens under this generic name without giving a mark of interrogation.

The pinnules of the present specimens are exceedingly delicate, strongly resembling those of the specimen V2151a in a Rufford collection figured by Seward (1894, pl. 3, fig. 1). The marked difference in size of this example led Seward to consider the advisability of instituting a variety *O. mantelli* var. *minor*, but such a course, as Seward emphasized, would merely serve to multiply terms and would not be supported by any characters of trustworthy value as regards natural affinity. The writer is in complete agreement with Seward's statements, who says, for instance:

> A difference in size, although strongly marked, is not a character to be lightly insisted on as a basis for a species or variety when we are dealing with fragments of fossil plants (1894, pt. 1, p. 48).

The generic name *Onychiopsis* was instituted by Yokoyama for a Japanese species originally described by Geyler (1877) as *Thyrsopteris elongata*, and afterwards referred to by Yokoyama as *Dicksonia elongata*. Yokoyama pointed out the resemblance between the fertile pinnae of the Japanese specimens and those of the recent genera *Onychium* and *Gymnogramme*, especially of the former. The exceedingly intimate connection between Yokoyama's species and the English specimens led Seward to follow the suggestion previously made by Nathorst and to change the well-known *Sphenopteris mantelli* Brongniart. to *Onychiopsis mantelli* (Brongniart). This substitution for a provisional generic name calls attention to the botanic affinity with the Wealden flora.

The valuable evidence as to the existence of an *Onychium* type of fern in late Mesozoic time has been reported from England, Portugal, North Germany, Bohemia, Japan, North America and several other places, possibly also from Queensland and New Guinea. In China several specimens of the *Onychiopsis* type, probably *O. mantelli*, together with *Ruffordia göpperti* and *Podozamites* have been collected by Barbour in the early Cretaceous strata in Kalgan (see Garbau, 1928, pt. 2, p. 678), and from the Lower Cretaceous beds in Touli of the Fangshan district in Hopei, Mr. C. H. P'an described some specimens under the name of *O. psilotoides* (Stockes and Webb) Ward (1933, p. 534, pl. 1, figs. 1–5).

The present specimens from the Pantou series are hardly sufficiently well preserved to enable us to give any satisfactory detailed diagnosis.

CLADOPHLEBIS sp. (cf. C. DUNKERI Schimper)
Figure 15

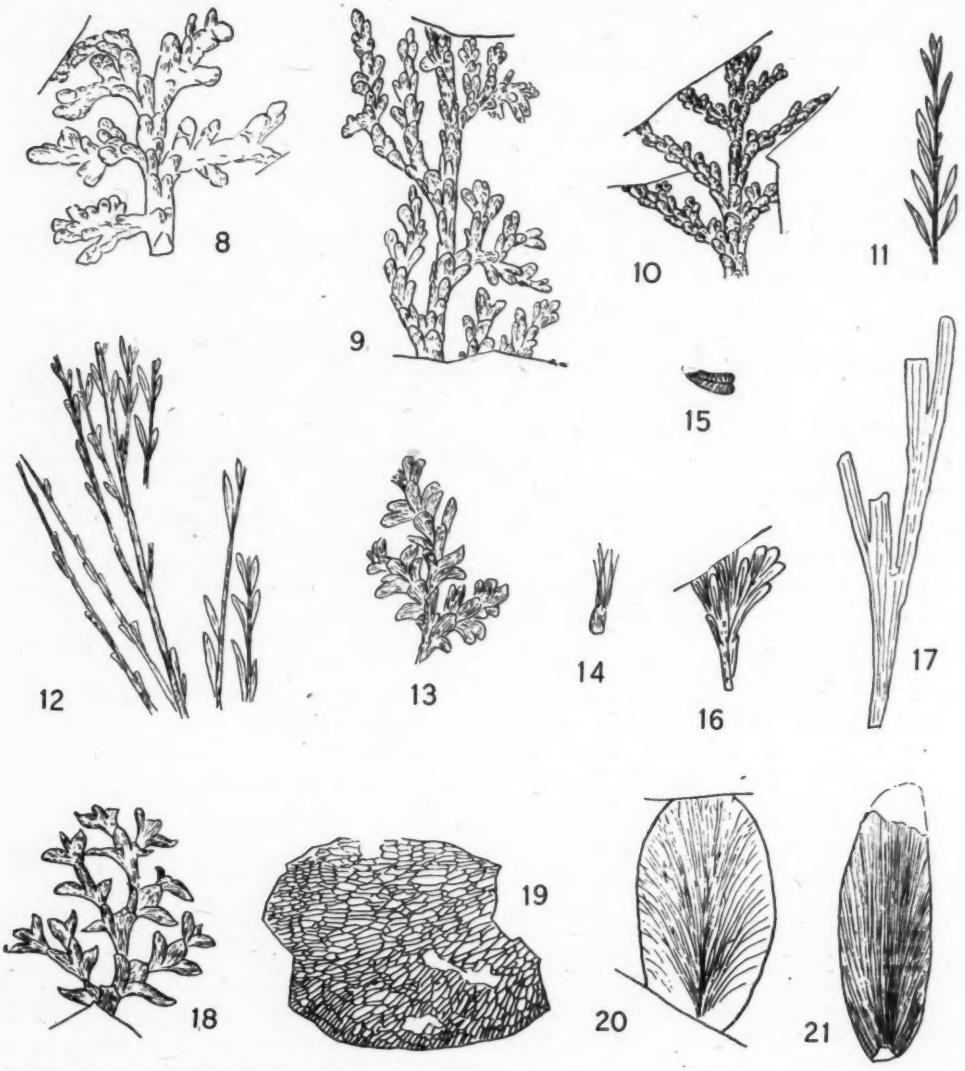
The small fragment of a single pinnule, shown in figure 15 more closely resembles *Cladophlebis dunkeri* (Schimper) than *C. browniana* (Dunker). The material is however, too meagre to permit of a definite specific determination. The pinnule is very small, not quite reaching 5 mm. in length, somewhat falcate, possessing a marked midrib reaching almost to the apex and obliquely ascending, more or less arched secondary veins, which bifurcate only once near the midrib.

The small pinnules of the examples figured by Nathorst (1890, pl. 4, fig. 1) as *Pecopteris geyleriana*, n. sp. from the Japanese Wealden also very closely resemble the present species.

SAGENOPTERIS YUNGANENSIS Sze, n. sp.
Figure 20

This species is represented only by a single leaflet, of which both counterparts are preserved, the better one is shown in figure 20. There is no trace of a leaf-stalk. The leaflet is small, obovate or elliptical, with an entire margin. The venation is feebly indicated, more or less reticulate, the meshes elongated in the direction of the long axis of the leaf, there is a fairly distinct midrib near the point of attachment, but it rapidly dies out towards the apex. This specimen shows a close resemblance to the Wealden from *Sagenopteris mantelli* (Dunker) figured by Seward (1894, pl. 9, fig. 4). The leaflets of our species are smaller and more elliptical than those of the English species, and it is quite conceivable that the finding of more specimens from the Pantou series may compel us to recognize more definitely this close agreement between the two forms.

The genus *Sagenopteris* has long been considered to be water ferns belonging to the



FIGS. *8–10*—Cf. *Sphenolepidium elegans* (Chow), ×1.75. (p. 51)
11, 12—*Onichiopsis?* sp., ×1.75 (p. 46)
13, 18—*Pagiophyllum gracile* Sze, n. sp., ×1.75 (p. 51)
14—Fructification, ×1.75. (p. 53)
15—*Cladophlebis* sp., cf. *C. dunkeri* Schimper, ×1.75. (p. 47)
16—*Sphenopteris* sp., cf. *Ruffordia göpperti* Dunker, ×1.75. (p. 45)
17—*Baiera* sp., ×1.75. (p. 52)
19—*Sagenopteris? dictyozamioides* Sze, n. sp., ×1.75. (p. 49)
20—*Sagenopsis yunganensis* Sze, n. sp., ×1.75. (p. 47)
21—*Otozamites* sp., cf. *O. klipsteinii* Dunker, ×1.75. (p. 49)

family *Marsileaceae*. The frequent occurrence of this genus in association with the fruits of the caytonialean plants led Thomas and others to believe that the genus *Sagenopteris* might be the foliage of the Caytoniales. The Caytoniales were probably not ancestral to the modern angiosperms but may have represented a side branch of the ancestral stock that ranged back into Upper Triassic.

SAGENOPTERIS? DICTYOZAMIOIDES Sze, n. sp.
Figure 19

In this leaflet the venation is particularly clear; there is no distinct indication of a midrib. This leaflet agrees in shape and in the form of the venation with the specimen V 2353 in the Rufford Collection (Seward 1894, pl. 9 fig. 5) but the venation is more reticulate and denser. The meshes elongated in the direction of the long axis of the leaflet. The venation type of the present example strongly recalls that of the genus *Dictyozamites*.

The example is more or less asymmetrical; and it is somewhat doubtful whether it should be referred to *Sagenopteris*. There is a certain resemblance to the wings of insects but the venation type clearly indicates that it must be foliage of plants. The writer places this specimen with a mark of interrogation under the genus *Sagenopteris*, pending the discovery of additional material that may clear up the obscure nature of the reticulation.

PTILOPHYLLUM BOREALE (Heer) Seward
Figures 1, 2

A few specimens from the Pantou series resemble this well known arctic species. Some of the best preserved examples are shown in figures 1 and 2. The example shown in figure 2 represents a basal part of the leaf. This example is characterized by the small pinnae attached to the upper face of the rachis, the stoutness of which is a noteworthy feature. The pinnae are closely approximated, linear, lanceolate, more or less elongate, acute, attached obliquely, the base of the lamina is truncate or somewhat rounded. The veins are equal, slender and parallel. Another example shown in figure 1 may represent a middle part of the leaf. The pinnae are relatively broader, less obliquely attached, nearly at right angles to the rachis with a slightly falcate and acute apex, the upper margin of the lamina is almost straight, and the lower edge curves abruptly upwards at the apex. The veins are more or less spreading at the base but for the most part parallel.

The specimens agree in shape, form and size, and in fact almost in all respects with the typical Greenland representatives of the species, and there is no doubt as to their specific identity (see Seward, 1917, p. 526, fig. 597).

The species *Ptilophyllum boreale* was originally described by Heer under the generic name *Zamites*. Heer described in 1875 numerous well-preserved impressions of pinnate fronds from the Lower Cretaceous plant beds of Kome, Greenland, which he referred to several species of *Zamites* though the differences between them according to Seward are hardly of specific rank. Halle employs *Zamites* for fronds with linear pinnae attached to the upper face of the rachis by a base which is somewhat, but often very little, rounded and always asymmetrical, with or without a basal callosity. Fronds of the type of *Z. gigas* he includes in the section *Euzamites*, while *Z. borealis* and similar forms are referred to a second section, *Subzamites*. Seward dealt with the relation and the limitation between *Ptilozamites*, *Zamites* and *Otozamites* at length, he then transferred Heer's arctic forms *Z. borealis*, *Z. pusillus*, *Z. anderssoni* and *Z. antarcticus*, described by Halle (1913) from Graham Land, to the genus *Ptilophyllum* as types agreeing very closely with *Ptilophyllum pecten* (Lindley and Hutton) and in some cases not clearly distinguishable from it even specifically. The cuticle and the stomata structures of a pinna of *P. boreale* are according to Seward precisely like those of *P. pecten* (see Seward, 1917, p. 525).

OTOZAMITES sp. (cf. OTOZAMITES KLIPSTEINII Dunker)
Figure 21

In the Pantou series are found several detached segments of *Otozamites;* they appear to be more closely comparable to *O. klipsteinii* (Dunker) Seward in the European Wealden. In figure 21 is represented one of these detached segments. This example, 20

mm. in length, is imperfectly preserved. The characteristic auriculate base is not well marked. The veins are numerous, radiating from the point of attachment towards the margin of the segments. This example may possibly be the segments of the terminal portion of a frond of *Otozamites*. It agrees fairly well with the terminal segments of *Otozamites klipsteinii* figured by Seward (1895, pl. 1, fig. 3) in the Wealden Flora and in his Fossil Plants, vol. 3, p. 545, fig. 608. But the material is too scanty and too imperfect to admit of more exact determination.

Nilssonia sp.
Figure 5

There is only one specimen of this genus. The segments are fairly uniform in breadth and linear, they reach 18 mm. in length and are usually 4–5 mm. broad; the distal end is truncate, the lower edge strongly curved. The veins are not clearly visible, they appear to be simple and parallel. The lamina shows clearly the attachment to the upper surface of the rachis, which is covered by it as in all species of this genus. A first glance at this example suggests that it presents a very similar appearance to that of the Jurassic species *Pterophyllum nathorsti* Schenk, but on close inspection of the lamina on the rachis, it represents clearly a species of *Nilssonia*, because the bases of the segments meet almost in the middle of the upper face of the rachis.

The Wealden species that bears a close resemblance to the present specimen is *N. schaumburgensis* Dunker. But the segments of *N. schaumburgensis* are usually shorter and broader, scarcely uniform in size, and in some specimens the lamina is almost entire. The specimens figured by Dunker (1864) from the Wealden formation of north Germany show a considerable variation in size and form; this variable character is also well brought out in the later and more perfect figures in Schenk's monograph. Seward (1895, p. 55, fig. 3, a–c) figured some specimens from the English Wealden; they show the same variable character of the segments. Nathorst (1890, pl. 1, figs. 6–9a) records from Japan specimens of what is most probably the same species as the English and North German forms. The variation in the size and division of the lamina is well illustrated in these Japanese examples.

The present specimen may represent a separate or new specific type of this genus, the material, however, appears too scanty for the creation of a new species.

Brachyphyllum obesum Heer
Figures 3, 4

The most frequent species in the present material is the above named. The specimens are not well preserved. The contrast between the matrix and the plant—hardly any coal is preserved—is not great, so that it is difficult to draw the specimens with any accuracy. The best specimen is shown in figure 3. The breadth of the axis is fairly uniformly about 5 mm. in thickness. The leaves or leaf scars are squamate, more or less rhombic in outline, closely appressed to the axis. This specimen agrees fairly well with the specimen V2137a in Rufford Collection figured by Seward (1895, pl. 20, fig. 2) from the English Wealden. It is also identical with the specimens described by Chow from the Laiyang district in Shangtung. Another specimen (fig. 4) does not show the leaf form very clearly, but the manner of branching is well illustrated; similar to the examples figured by Seward in his plate 17, figure 9 (V3348) and in plate 20, figure 1 (V2137). This form may be distinguished from Heer's species by their more slender branches, which are less thickset, more elongated and subdivided; but it must be admitted that the grounds for a specific distinction are extremely slight, and we may not unreasonably regard the two sets of specimens as specifically identical. The habit of this specimen agrees closely with that of *B. obesiforme elongatum* Saporta (1864, p. 176, pl. 31, fig. 14) from the Lower Cretaceous in Portugal. This form appears to be closely allied to *B. obesum*. According to Seward the new species *B. crassicaule* instituted by Fontaine (1889) for some Potomac specimens is perhaps a somewhat unnecessary addition to specific nomenclature and may be a synonym of Heer's species. The Jurassic species *Brachyphyllum gracile* Brongniart appears almost identical with some forms of *B. obesum* and as Seward (1895, p. 220) says:

such comparisons might however be considerably increased, but without leading to any satisfactory conclusions.

From the Lower Cretaceous beds of Shangtung, Chow described besides *B. obesum* Heer another two new species, *B. magnum* and *B. multiramosum*. If we compare the figures of *B. magnum* Chow and *B. multiramosum* Chow with Heer's species, we find a striking resemblance, e.g. Chow's plate 1, figure 1 and plate 2, figures 1–2 and his plate 1, figures 2–6. A first glance at Chow's specimens (pl. 1, fig. 1 and figs. 2–6) suggests two specific forms, but on close inspection of the figures, a difference in breadth of the axis appears to be the only real distinction, and in view of the correspondence in habit, this alone is hardly of sufficient importance to necessitate the separation of an independent species. Possibly the specimens of *B. multiramosum* Chow should be regarded as a distinct species, but the evidence, too, is hardly sufficient to justify a separation from *B. obesum* Heer. The more numerous small rami of the branches is not a reason for creating a new species.

Cf. Sphenolepidium elegans (Chow)
Figures 8–10

In the Pantou series are found many fragmentary specimens that appear to be more closely comparable with the examples figured by Chow as *Sphenolepis elegans*, n. sp., from the Laiyang formation in Shangtung. The branches are slender, with the twigs given off alternately at a fairly wide angle. The leaves are small, imbricated, and closely appressed to the axis. This species is characterized, according to Chow, by having one or two small leaves in the axis from which the lateral twigs are given off. The writer has failed to find any such small leaves on the middle axis of the present specimens. The preservation of the present specimens is too imperfect to allow of any satisfactory comparison. No cone-bearing examples were found in the material.

The generic name *Sphenolepis* proposed by Schenk in 1871 was changed by Heer to *Sphenolepidium* on account of the previous use of the name by Agassiz as a genus of fishes. The name *Sphenolepidium* should be, according to Seward, restricted to specimens that can with reasonable certainty be connected with cone-bearing examples. Many of the specimens recorded as *Sphenolepidium* afford no evidence as to the nature of the cones and should therefore be assigned to *Pagiophyllum* or *Brachyphyllum*. It is indeed almost impossible to determine the specific limits of the present examples and the small branches of *Brachyphyllum*. The leaves of the present examples are ovate, appressed, agreeing with those of *Brachyphyllum* or with some examples intermediate between the type of foliage assigned to *Pagiophyllum* and *Brachyphyllum*. Seward (1919, p. 364, fig. 771) figured an example from the Wealden of Sussex as *Sphenolepidium kurrianum* (Dunker) and pointed out:

> The Wealden specimen reproduced in fig. 771 is placed in *Sphenolepidium* because of its association with branches, identical in habit, bearing cones; if found as an isolated fossil, it would be referred to *Brachyphyllum*.

Both the present specimens and those from Shangtung are preserved in sterile foliage shoots, bearing no remains of cones. It would be better therefore to place Chow's *Sphenolepis elegans* under the genus *Brachyphyllum* or *Pagiophyllum*. The example figured by Chow as *Sphenolepis arborescens*, n. sp., bears a decided resemblance to his *Sph. elegans;* there cannot be much doubt as to their specific identity. Also the example described by Chow (1928, pl. 2, fig. 4) as *Palaeocyparis* cf. *flexuosa* Saporta bears a strong resemblance to the present species. There would seem to be no satisfactory evidence to warrant a separation between these two forms.

No cones of the type of *Sphenolepidium* have been described that throw any light on the affinity of the genus; like many others, e.g. *Brachyphyllum, Pagiophyllum, Thuites* etc., it must be left for the present in the category of Coniferae incertae sedis.

Pagiophyllum gracile Sze, n. sp.
Figures 13, 18

The small examples shown in figures 13 and 18 are of some interest, because they seem to represent a new form of the *Pagiophyllum* type. The examples are very fragmentary, but sufficient to give a good idea of the shape of the leaves. The slender axis

bears somewhat distant alternate branches. The leaves are leathery, thick, falcate, more or less triangular in outline with acute or obtuse apex, spreading, slightly decurrent, spirally arranged, somewhat whorled on the branches. There is no trace of a median keel, possibly because of the probable great thickness of the leaf, but the surface shows a fine longitudinal striation. The example agrees well with *Pagiophyllum crassifolium* (Schenk) figured by Seward (1895, pl. 16, figs. 1, 2) from the English Wealden, but differs from the latter in the smaller, thicker and less falcate leaves. The present example is also very similar to the Jurassic species *Pagiophyllum peregrinum* (Lindley and Hutton) but the vegetative shoots of the latter species bear more crowded, imbricate, broader and more tetragonal leaves, and there is a distinct dorsal keel and occasionally rows of papillae are visible on the lamina.

The genus *Pagiophyllum* is a purely artificial and provisional genus: as Solmsbach says: "It is only in accordance with old custom to distinguish the Ullmaniae of the Zechstein from *Pagiophyllum*." Seward also points out the difficulty of drawing any clearly defined line between *Pagiophyllum* and some forms included in *Brachyphyllum*. He says for instance:

> . . . but the distinction between *Brachyphyllum* and *Pagiophyllum* is in many cases by no means well marked, and neither term is more than a convenient generic name which does not imply any precise botanical affinity (Seward, 1895, p. 216).

In dealing with some intermediate forms of the present specimens we have indeed to face the difficulty of deciding upon the most suitable generic terms. And it is also not impossible that the specimens here described as cf. *Sphenolepidium elegans* (Chow) (figs. 8–10) might be a species of *Brachyphyllum* or *Pagiophyllum*.

Pagiophyllum is widely distributed in Jurassic strata and extends into Cretaecous and Tertiary rocks. It occurs also in Pre-Jurassic floras and has been described by Zeiller from the Permian of France. As Seward (1919, p. 274) says:

> It should be recognized that this extended use of the name is not in accordance with general practice, but it is adopted on the ground that, as in recent conifers so in the case of extinct types, similarity in the habit of vegetative branches does not necessarily imply close relationship as regards the more important characters of the reproductive shoots.

THUITES? sp.

There are a few specimens in the present collection that differ from the specimens referred to *Brachyphyllum* and *Pagiophyllum* in having more leaves arranged in whorls, two in each whorl. They agree well with Seward's Wealden species *Thuites valdensis*. and are probably identical with this form. The characteristic opposite branching is not clearly seen in our examples.

PODOZAMITES? sp.
Figures 6, 7

The detached leaves shown in figures 6 and 7 probably belong to the genus *Podozamites;* but they are too badly preserved to be determined specifically. The lamina is smaller than all the known species of this genus, short and broad with a blunt apex, and gradually contracted at the base. The examples are comparable with the Jurassic species *Podozamites kidstoni* Etheridge from Afghanistan (see Grabau 1928, pt. 11, p. 290, fig. d) and with the similar small leaves figured by Chapman (1909, p. 103) from Jurassic rocks in Victoria, Australia. A similar though not identical form is described by Nathorst (1876, p. 53, pl. 13, fig. 51), as *P. ovalis*, distinguished by its broadly rounded and mucronate apex.

The writer (Sze, 1931, pp. 15–19) has made a critical revision of nearly a hundred species referred to *Podozamites*. The only two species that should be retained in this genus are *P. lanceolatus* (Lindley and Hutton) and *P. schenki* Heer. All the other species are either indeterminable or questionable. Leaves of the type of *P. kidstoni* and *P. ovalis* etc. are of very obscure nature. For such specimens as occur in the present collection it is impossible to arrive at any satisfactory conclusion as to the real nature of the species. The generic name *Podozamites* assigned to it, is rather for the purpose of convenient reference than intended to convey the idea of a well-defined type.

BAIERA sp.
Figure 17

The small fragment shown in figure 19 and another similar fragmentary impression

represent the only determinable leaves of *Baiera* in the collection. The species is characterized by the deep dissection of the lamina into very narrow, linear and parallel segments and by the presence of a slender petiole. The specimen, though fragmentary, is hardly distinguishable from the Jurassic species *B. lindleyana* (Schimper). It is also comparable with *B. brauniana* (Dunker) from the Wealden and Upper Jurassic rocks. Another comparable species is described by Nathorst as *B. spetsbergensis* from Upper Jurassic rocks of Spitsbergen; it is characterized by the very narrow but apparently cylindrical segments and, except in its smaller size, resembles *B. lindleyana*.

FRUCTIFICATION
Figure 14

In figure 14 has been figured a small object of very obscure nature. This object shows a certain superficial resemblance to the fruit referred to *Cypselites truncatus* Heer of the family Compositae (see Gothan 1921, p. 405, figs. 4, 5) but there is certainly no real relation. It is difficult to conceive that in view of the absence of any trace of other angiosperms, the forerunner of Compositae should be found in our Pantou series. Since only a single example has been found, it seems better to leave the object unnamed.

GEOGRAPHICAL RELATIONSHIP OF THE FLORA

The most important species of the Pantou series is *Ptilophyllum boreale* (Heer) Seward. An inspection of the present specimens with the example refigured by Seward (1917, p. 526, fig. 597) confirms that these two forms are almost identical. They agree with each other in form, habit and size. This characteristic arctic species is hitherto only known from the Lower Cretaceous plant beds of Kome, Greenland. Its occurrence in the Pantou series in Yungan is therefore very striking. In the shape of the pinnae, including the characters of the base, this species agrees closely with the fronds grouped under *Ptilophyllum pecten* (Phillips) widely distributed in Jurassic floras from many localities in Europe, from Turkestan, India, Graham Land, Patagonia and elsewhere. The other more frequent species is *Brachyphyllum obesum* Heer. This species was originally created by Heer in 1881 from the Lower Cretaceous strata of Almargen in Portugal and was later in 1894 described by Saporta from the Aptian of the same land. Seward figured some specimens under this name from the English Wealden. According to Seward the new specific term instituted by Fontaine as *B. crassicuale* for some Potomac specimens in North America is perhaps a somewhat unnecessary addition to specific nomenclature, though Fontaine does not apparently draw attention to the very close resemblance between these two species. Among the numerous conifers figured by Saporta from Jurassic strata we have such species as *B. nepos* (Saporta) and *B. desnoyersii* (Brongniart) and other forms that resemble this Wealden species in a greater and less degree. The small fragmentary sphenopteroid example is too imperfect to admit of exact determination, but its close resemblance in habit and shape with the Wealden species *Ruffordia göpperti* of England, North Germany and Japan is certainly undeniable. The small detached pecopteroid pinnules referred to *Cladophlebis* sp. agrees in form and size closely with *Cladophlebis dunkeri* (Schimper) Seward of the Wealden and it is, the writer believes, almost impossible to place much confidence in our attempts to distinguish these two forms. This form comes also rather near to other Wealden species, *C. browniana* Dunker and *C. geyleriana* Nathorst. The other fern-like examples that have been described by the writer as *Onychiopsis?* sp. may represent a very characteristic type. They seem to be most nearly comparable to the Wealden species of *Onychiopsis*. The type is apparently suggestive of certain Wealden forms, though the material is too meagre for definite determination. The genus *Onychiopsis* has been recorded by Engelhardt from the Cenomanian of Niederschona. As Zeiller (1892–1893, p. 8931) has pointed out, this discovery of a Wealden fern in rocks referred to a higher horizon in the Cretaceous system is of considerable interest. There is a resemblance worthy of note between the Wealden species *Sagenopteris mantelli* (Dunker) and the present two new species, *S. yunganensis* and *S. dictyozamioides*. A leaflet of *Sagenopteris* figured by Hosius and Von der Marck from the Neocomian sandstone of the Teutober-

gen Wald under the name *S. neocomiensis* resembles also closely *S. mantelli* and the present specimens, differing only in having a more distinct midrib. The genus *Sagenopteris* is known from the Rhaetic to the Wealden. As residual remains or relics, it may be preserved in Upper Cretaecous (Bohemia and Sakhalin) and even in Eocene intermingled with Tertiary plants (Alaska). The specimen of *Nilssonia*, n. sp. shows a striking resemblance to *N. schaumburgensis* Dunker of the English and Japanese Wealden, for there appears only a certain difference in the breadth of the segments. The genus *Nilssonia* is especially characteristic of Jurassic and Rhaetic floras, it occurs also in Triassic beds, and extends into Cretaceous floras. It may be found as a relic in the Upper Cretaceous strata of Bohemia, Japan and Sakhalin. The detached segments of *Otozamites* are specifically almost indeterminable, but they may represent the leaflets of the terminal portion of a frond of *O. klipsteinii* (Dunker) from the English Wealden. This species has been also described by Kawasaki in the Lower Cretaceous beds of Korea. The genus *Otozamites* is a very widely spread Jurassic type, and extends from Triassic to Lower Cretaceous rocks. The fragments of *Baiera* sp. bear a decided resemblance to the Lower Jurassic species *B. lindleyana* (Lindley and Hutton). This species is recorded also from Middle Jurassic rocks in Chinese Dzungaria and from Upper Jurassic rocks in Scotland. Some specimens described by Fontaine from the Lower Cretaceous in the Black Hills as *Czekanowskia nervosa* Heer, as Berry points out, probably are leaves of a *Baiera*, and Seward is disposed to refer them to *B. lindleyana*. The other plant remains, which are of very obscure nature, are too badly preserved for an exact determination. The writer therefore leaves those aside, more particularly for the reason that they are of no value for stratigraphical purposes.

While a fuller knowledge of the flora is still desirable, the evidence available at present points distinctly to a Lower Cretaceous or Wealden age for the Pantou series. The flora of the Pantou series is apparently allied to or identical with the Wealden flora of Europe and with the older Potomac flora of North America despite the presence of Jurassic elements, despite the fact that certain forms can be found in higher horizons, e.g., *Brachyphyllum obesum* in the Aptian and *Onychiopsis* in the Cenomanian, and despite the fact that the genera *Sagenopteris* and *Nilssonia* can be found as relics in the upper Cretaceous strata, and the former even in the Eocene. Looking at the present specimens collectively, we notice a very striking agreement with the flora of underlying Jurassic beds. It is indeed very difficult to point to any well-marked or essential difference between the plant life of the Jurassic and the Wealden. The evidence of palaeobotany, as Seward points out, certainly favors the inclusion of the Wealden rocks in the Jurassic series. Mr. M. K. Chern (1942, p. 9) the coiner of the Pantou series would like to refer this formation to the Upper Cretaceous. In the absence of any undoubted remains of angiosperms from the Pantou series, the writer is inclined to believe that the palaeobotanical evidence at hand is not quite sufficient to prove an Upper or even a Middle Cretaceous age. Among the present specimens there are none which can be regarded as the earliest angiosperms. Mr. C. S. Kao and the writer searched in vain for any fragments of monocotyledonous or dicotyledonus plants during the field investigations.

All the palaeobotanical evidence considered together, it seems most convenient, as a working hypothesis, to regard the base of the Pantou series as representing the beginning of the Cretaceous in the province of Fukien.

The most interesting point of the Pantou series is that it contains among the plants fossil fishes more or less comparable to *Lycoptera sinensis* Smith-Woodward and the small phyllopod shells *Estheria*, probably *E.* cf. *middendorfi* R. Jones. Both forms have been found in the Laiyang formation in Shangtung. The Laiyang formation has furnished undoubted Lower Cretaceous plants, mostly conifers, which have been described by T. C. Chow (1928, pp. 136–140) in a short paper. The fish beds with *Lycoptera sinensis* among the plants are well developed in eastern Shangtung, especially in Laiyang-Hsien and Chao-Hsien. These strata are, according to Grabau, probably to be interpreted as playa deposits, the fish and plants being swept into the shallow lake

basin, with the fish dying as the water evaporated and becoming buried in the fine silt which settled on them. The same is true for the deposits of the Pantou series. It represents apparently the deposits of fresh-water basins. Just like the Laiyang formation, the most abundant and almost the dominant plants of the Pantou series are the conifer remains. *Brachyphyllum obesum*, *Sphenolepidium elegans* and *Pagiophyllum* sp. are common in both of those formations. The Pantou series in Fukien is therefore undoubtedly equivalent to the Laiyang formation in Shangtung, and it is highly probable that the similar fish beds with *Lycoptera* in other parts of China and those of Mongolia and Transbaikalia as believed by Prof. Grabau (1928, p. 652) are of the same age.

The conclusion forced upon the writer by a comparison of Chow's figures is that the forms *Brachyphyllum magnum* Chow and *B. multiramosum* Chow are not separable into well-defined species and should all be included in *B. obesum* Heer. Likewise the species *Sphenolepidium arborescens* (Chow) is habitually identical with *Sphenolepidium elegans* (Chow). Possibly the specimen figured by Chow as *Palaeocyparis* cf. *flexuosa* Saporta might also belong to this form. The specimen described by Chow as *Thinnfeldia* sp. is certainly not of accurate determination. The frond of *Thinnfeldia* is mostly only monoprimate but scarcely bipinnate. Specimens with forked frond and with the odontopteroid segments have been separated by Gothan as a distinct genus *Dicröidium*, characteristic only in the Gondwana Lands. Also Chow's specimen, though with the forked habit, is not comparable to the Gondwana forms. The writer would prefer to determine this example as planta incertae sedis.

The abundant insect remains described by Grabau as *Sinoblatta*, *Samarura*, *Proteroscarabaeus* and *Laiyangia* in the Laiyang formation are still not recorded in the Pantou series. We have found only one or two fragments of wings of very obscure nature, and it is to be hoped that the fossil insects may be found in future search in the Pantou series.

Another interesting occurrence of the lower Cretaceous plants is in the vicinity of Touli and Tahuichang of the Fangshan district southwest of Peiping (Peking). The plant remains described by C. H. P'an (1933 p. 533–538) are *Onychiopsis psilotoides* (Stokes and Webb) Ward, *Cyparissidium?* sp., *Elatocladus* sp., *Pityophyllum* cf. *staratschini* (Heer), *Podozamites lanceolatus* (Lindley and Hutton) Braun, and *Conites* sp. Also here the conifers are the dominant plants. The specimen figured by P'an as *Cyparissidium?* sp. might be the small branches of *Brachyphyllum* and the small cone figured by P'an in plate 1, figure 13 as *Conites* sp. might belong to the genus *Sphenolepidium*. The specimen agrees in shape and size with those figured by Seward from the English Wealden (especially Seward, 1895, pl. 17, figs. 7, 8). The English examples are in direct connection with the branches of the *Sphenolepidium* type. The pinnules of *Onychiopsis psilotoides* are closely comparable to those of *Onychiopsis?* sp. of the Pantou series. The small phyllopod shells *Estheria* were also found in the black shales below the plant beds. The plant remains closely resemble those of the Wealden of England and Japan. Also here the field geologists seem to be more inclined to assign the plant beds to the upper part of the Cretaceous, despite the absence of any undoubted remains of angiosperms (see P'an, 1933, p. 538).

The Lower Cretaceous sediments containing plant fossils and coals are well developed in the Kalgan area. Barbour reports as the most abundant types found by him in these strata besides *Podozamites*, ferns closely resembling *Ruffordia* (*Sphenopteris*) *göpperti* and *Onychiopsis mantelli*, species characteristic of the English Wealden. On examining the other plant fossils collected by Barbour, T. C. Chow remarks as

> different from any so far reported from other parts of China and unlike the flora of the Jurassic beds in the Western Hills of Peking. (See Grabau, 1928, p. 678.)

Both the forms *Ruffordia göpperti* and *Onychiopsis* are the characteristic fossils of our Pantou series. No fish remains and *Estheria* have been recorded from the Kalgan sediments. In determining the geological age of these deposits Prof. Grabau (1928, pp. 678–679) states as follows:

> There seems little doubt that these Kalgan continental deposits are of early Cretaceous age and

were formed after the elevation of the Yenshan range on the south as outwash gravels and sands forming extensive subaerial deltas or alluvial fans and river floodplains. As such they are regarded by Berkey and Morris, as well as by Barbour and myself. There is no inherent difficulty in believing that Cretaceous deposits of these northern basins may contain coal beds, indeed judging from their general character and the evidence furnished by the vertebrate fauna from beds of this age in Mongolia, surprise may be expressed that Cretaceous coals are not more wide-spread in this region.

The fish-bearing beds are also found in the district Chaoyang and Lingyuan of Jehol Province. The fishes differ, according to Grabau, markedly from those found in either the Shangtung or the Ordos basins, but show some relationship to *Lycoptera middendorfi* of the Transbaikal region. Besides the fishes, a few plant remains provisionally referred to the genus *Czekanowskia*, fragments of insects and *Estheria* and a single pelecypod shell, *Corbicula*, have been found. As Grabau (1928, pp. 673–674) remarks:

> The age of these beds was formerly held to be Jurassic, but the evidence afforded by the plants, insects and mollusks of the corresponding fish-beds and other deposits of Shangtung suggests a Lower Cretaceous (Wealden) age for these beds also, for the fish of the two regions were most probably contemporaneous, since they are so closely related.

Unfortunately the plant remains have not been described and figured. The genus *Czekanowskia* is very widely spread in Jurassic floras, and only a few examples are recorded from Cretaceous strata. The equivalence of the geological age of these beds with our Pantou series is, however, not impossible according to the evidence furnished by the fishes, the plants and the phyllopods (*Estheria*).

Remains of small insects and shells of *Estheria* as well as plant remains have been collected by Andersson and Yuan in certain beds of the Liupanshan series in the Shensi-Kansu regions. These have so far failed to furnish a clue, according to Grabau, as to the precise horizon of these beds, though they appear to indicate Cretaceous. The plant fossils remain also undescribed. The name Liupanshan series is, after Grabau (1928, p. 667), better restricted to the beds above the fish-bearing horizons, which are the equivalent of the Laiyang shales of Shangtung, and like them, of Lower Cretaceous age.

In southwestern China, a few plant remains were described by Yokoyama in 1906 from two localities within the Mesozoic basin of Szechuan. The first of these is Shikuantzu in Chaohuahsien northeast of Chengtufu and near the northern boundary of the basin. The plant-bearing rock occurs with coal seams and is a dark-gray friable shale, in which the plants seem to be fairly abundant. Three species have been identified, namely, *Coniopteris nitidula*, *Glossozamites hoheneggeri* and *Podozamites lanceolatus*. The second locality is Schichimiao, Hochow east of Chengtu, and lies within the basin. The rock is a light-grey cleavable shale associated with coal layers. In addition to the above named *G. hoheneggeri*, there has been found another species of cycad, *Glossozamites* i.e. *G. acuminatus* besides an indeterminable species of the fern *Cladophlebis*. These species indicate, according to Grabau (1928, p. 650), a Wealden age for the formations in question. The plant fossils as well as the lithological characters are not comparable to those of the Pantou series.

Beds apparently referable to the Wealden of Europe occur, according to Frech, on the right bank of the Yangtze 5 li above Futchow, Tshungkingfu in Szechuan. The same formation is shown farther east on the Yangtze at Tzekwei district (=Kweichow Fu) in western Hupeh and on the Taning-ho where it was named the Kweichow formation by Willis and Blackwelder. This term has since been restricted to the Upper division of the series so named by Willis and Blackwelder, by exclusion of the beds now known as the Hsingchi series of the Jurassic. No plant remains have so far been recorded from these rocks, but some well-preserved pelecypod shells of *Unio* and *Cyrena* occur. Both *Unio* and *Cyrena* are, according to Grabau (1928, p. 645), forms that appear to be closely related to species found in the European Wealden. The writer has paid much attention to searching for plant fossils in the so-called Kweichow series in the districts Tzekwei, Patung, Tangyang and Nanchang during a short journey in 1940, but no trace of any undoubted remains of plants were gathered. The Kweichow series in western Hupeh dominantly consists of

alternating beds of green sandstones and purple shales with thin green shaly intercalations. The same holds for the red basin of Szechuan. It consists of alternating banks and layers of red-brown ferruginous claystones and light-colored sandstones, the latter chiefly of eolian character. Thus the lithological character of the Kweichow series is not similar to that of the Pantou series.

The fish-bearing beds with plant fossils have also been found by Mr. P. Kao near the Woosih temple in the district Chuchi of Chekiang province. The fish beds are said to underlie the rhyolite (Kao, 1935, p. 59). The writer received in 1934 some specimens of *Cladophlebis* from the Showchang district from Mr. T. S. Liu of the Westlake Museum of Hangchow. The species is closely allied to or identical with *Cl. dunkeri* of the Wealden. Just like the rocks of the Pantou series, the matrix of the examples is a white or grayish paper shale. Fish remains were also reported to have been found in this locality. Now the question naturally arises: are there two fish- and plant-bearing series in south-eastern China in the Lower Cretaceous series, one resting upon the rhyolites as our Pantou series does and the other lying below these volcanic lava flows? In the province of Fukien, the Pantou series has long been wrongly interpreted by many geologists as underlying the lava flows. May this also be the case in the Chekiang province? This is a question that can only be settled by further investigations.

Our Pantou series is certainly equivalent to the Ryoseki series in Japan. The latter formation has a wide distribution in the province of Tosa and Awa in Shikoko Island; and of Kii, Kozuke, Iwaki, Rikuchu and Rikuzen on the main island of Honshu. The type-locality is at Ryoseki near Sakawa in Tosa province. Here the series begins with a coarse conglomerate resting on black shale and sandstone with plant remains of which some forms have been described by Nathorst. Among the most characteristic of these are *Ruffordia göpperti, Onychiopsis elongata, Cladophlebis browniana, Cl. geyleriana, Zamites buchianus, Ptilophyllum* cf. *cuthense, Nilssonia schaumburgensis*, etc. In the province of Awa next to the east these beds are exposed in the Katsuragawa basin at Sakamo, Fujikawa, Tamo and Mitini. The plant beds of Ryoseki series underlie the *Trigonia* sandstone and from them many plant remains have been obtained. The most characteristic species here are *Onychiopsis elongata, Zamites buchianus* and the conifer *Cyparissidium? japonicum*. In the province of Kii in southwest Honshu, this series is again exposed at Yuosa, where plant fossils have been found in a sandstone bed, which also contains *Estheria*. The most abundantly represented species at this locality is *Cladophlebis geyleriana*.

The Pantou series can also be correlated with the Lower Keisho formation of southern Korea. A description of the flora of the latter formation has been published by Kawasaki including the following forms: *Eboracia lobifolia, *Onychiopsis mantelli, *Cladophlebis dunkeri, Cl. geyleriana, *Ruffordia göpperti, *Sagenopteris phillipsi, Equisetites naktongensis, *Ptilophyllum pecten, *Otozamites klipsteinii, *Nilssonia shaumburgensis* and *Czekanowskia murrayana*. Those marked with an asterisk * have also been found in our Pantou series. The Keisho formation rests with apparent conformity on the Naktong series of Lower Jurassic age, though the flora would indicate that there might be a hiatus between the two series. This relationship is, however, seen only in north and south Keisho Do in south Korea, where the Keisho formation has an estimated thickness of 1,000 meters or more. Further north, however, in south Zenra Do and North Chusei Do the Keisho formation rests unconformably on ancient rocks.

The Pantou series can also be compared with the Nikanian series in the southern Ussuri region, including the vicinity of Vladivostock. This series has been regarded as belonging to the Upper Jurassic, but it has later come to be considered as in part at least of Wealden age. This is the case in the Suifun Basin of south Ussuri Land, where these Nikanian beds lie directly upon the crystalline rocks. A restudy of the flora from the strata in this basin by Krystofovich has shown the presence of *Weichselia reticulata*, a species found only in the Wealden and Neocomian. The most important species are, *Ruffordia göpperti, Onychiopsis elongata, Cladophlebis browniana, Sphenopteris suifunensis, Ctenis yokoyamai, Nilssonia*

schmidti, Elatocladus manchurica, Nageiopsis cf. *anglica, Cyparrissidium gracile, Elatides curvifolia*, etc. The flora here, just like our Pantou series, is relatively large in percentage of conifers. On the whole it appears to be very similar to the Ryoseki flora of Japan, the Keisho flora of Korea, and that of the Pantou series.

There are also Middle and Upper Cretaceous plant beds in Eastern Asia, and these are at present positively known only from Korea, Japan and Sakhalin. In Japan the chief representative of the Upper Cretaceous continental beds is the Hokobuchi sandstone of Hokkaido. The flora is completely different from that of our Pantou series. It consists of ferns, cycads, conifers and many angiosperms such as *Populus, Rhamnites, Protophyllum* etc. The genus *Nilssonia* occur as a residual remain or relic in these horizons.

The Lower, Middle, and Upper Cretaceous flora of Sakhalin Island has also been studied by Krystofovich. Three divisions based on plant remains are made by this author. The lowest division is called the Ainuan series. This series consists of light-gray sandstones and dark shales with coal, and is characterized by ferns chiefly of *Gleichenia* and *Asplenium* and by angiosperms, *Populus*. The age of this flora is probably Albian, corresponding to a part of the Kome series of Greenland. The middle division is called the Gyliakian series. It is characterized by a very rich flora of ferns, cycads, conifers and many dicotyledons. Its age is Cenomanian and Turonian. The genus *Sagenopteris* occurs as a Jurassic relic in this horizon. The overlying Orokkian series (Jonquière formation) of the Sakhalin Islands consists again of three parts: a lower plant-bearing series, a middle marine series with *Inoceramus schmidti*, and an upper plant-bearing species. At Cape la Jonquière a rich flora has been collected below the *Inoceramus* horizon. The angiosperms play a dominant part of this horizon. Also in this horizon, the species of *Sagenopteris* and *Nilssonia* are preserved as Mesozoic residuums. Kyrstofovich puts the Orokkian flora in the same rank with the Patoot beds and with the Haldem and Quedlingburg series in Europe, these being mostly Senonian and in part Turonian.

The upper Cretaceous plant beds have also been recorded in the Amur country. Krystofovich regards the flora of the Mount Boguchan on the Amur river, characterized by *Platanus heeri* as Upper Cretaceous, and he finds that the plants of Boguchan and de la Jonquière in Ussuri Land are very similar. He also considers that the flora of Simonova in west Siberia is surely Cretaceous.

It is evident that the fossil plants of the Pantou series are undoubtedly not in common with those found in the Middle, and Upper Cretaceous in Korea, Japan, Ussuri Land and Sakhalin Island. Even the flora of Ainuan series, i.e., the lowermost plant stratum of Sakhalin Island is quite different from that of our Pantou series. The writer thinks that Krystofovich rightly places the Ainuan series in the Albian age, a horizon higher than the Wealden.

From what has been said above about the geographical relationship of the flora, it is evident that our Pantou series cannot be younger than uppermost Lower Cretaceous. Mention has already been made that it is most convenient to regard the base of the Pantou series as representing the beginning of the Cretaceous. It is equivalent to the Laiyang formation of Shangtung, the plant beds of Touli and Tahuichang of Hopei, the plant beds of Kalgan, the Ryoseki series in Japan, the Lower Keisho formation in Korea and the Nikanian series in the southern Ussuri region etc. If the Pantou series is of Lower Cretaceous age, the underlying volcanic lava flows should be regarded as Upper Jurassic. This would not seem to be quite consistent with the statements of most geologists. It is important to note that, in discussing the age of continental deposits, most geologists have paid no heed to the evidence of plant fossils. On this occasion the writer would like to cite the words of Gothan and Sahni in a joint paper dealing with the fossil plants from the Po series of Spiti (N. W. Himalayas):

> Unfortunately the confidence of many geologists in fossil plants as indices of geological age is not great. But plants are worthy of consideration as well as the marine animals, though the horizons embraced by them may be bigger or more extended than in the case of marine fossils.

Of special significance is the fact that the relation of our Pantou series and the underlying rhyolite is quite in harmony with that of the plant-bearing beds of the Touli-Ta-

huichang area, southwest of Peiping (Peking), where the volcanic series lies also below the plant-bearing strata. If the plant-bearing beds of Touli-Tahuichang area be regarded as definitely Lower Cretaceous, the underlying volcanic series may well be placed, too, in the Upper Jurassic.

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AN OCCURRENCE OF LATE PLEISTOCENE MAMMALS IN THE SAN FRANCISCO PENINSULA

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ABSTRACT—The geologic occurrence near the city of San Francisco of land vertebrates of the late Pleistocene is described. The fossil-bearing beds overlie the Merced formation and in turn are overlain by Quaternary deposits of the Terrace formation. The fauna, consisting of mammoth, horse, bison, camel, ground sloth, and bird are represented by scattered skeletal remains, which are listed.

IN 1936 scattered remains of *Elephas* were discovered in a fresh roadcut near San Francisco on California State Highway No. 1 where it skirts the ocean shore at the 200 foot contour line due east of Mussel Rock, San Mateo County (NW. corner San Mateo Quad., U.S.G.S.; U.C. Mus. Paleontology loc. V-4018). Subsequent visits to this spot uncovered additional mammals and also the humerus of a bird (*Uria aalge*). The latter has already been described (Miller and Peabody, 1941). Collection and preparation of the material was done by the writer with assistance from the Museum of Paleontology of the University of California. The writer wishes to thank Doctors R. A. Stirton, A. H. Miller and G. D. Louderback of the University for helpful criticisms.

Occurrences of Pleistocene land vertebrates along the coast in the San Francisco area have been sporadic and usually represented by a single bone or tooth. Hay (1927) has noted a half dozen discoveries extending from 1873 through 1927. Each is an isolated occurrence of fragments of one animal. Ground sloth, mastodon, *Elephas*, and *Bison* are thus represented. No additional discoveries have been recorded. Thus it is interesting to find in the San Francisco area several upper Pleistocene mammals associated in the same strata.

Mussel Rock marks the point at which the San Andreas rift passes northwest into the Pacific to reappear again at Bolinas Bay north of San Francisco. The Franciscan is exposed southwest of the rift, while on the northeast it is buried by thick beds of the Merced formation. This particular area is described briefly by Lawson (1914), who mentions a "landslide" in the vicinity of Mussel Rock. About 20 acres of basal Merced in the immediate vicinity of this promontory have slumped down several hundred feet as a result of movement along the rift. It is on the southern edge of the slumped area and nearly on the Merced-Franciscan contact that the terrestrial Pleistocene beds were discovered. State Highway No. 1 runs southwest across the landslide and cuts through the ridge opposite Mussel Rock. The roadcut evidently destroyed most of the vertebrate-bearing strata, and occasional shifting of the roadbed inland as the Pacific rapidly cuts into the soft Merced will soon obliterate it entirely.

The excavation of the cut exposed a graphic geologic cross section on the east bank (fig. 1). The west bank contains no such section. On the contrary it is formed of crumpled Merced and fault-gouge clay so close is it to the Merced-Franciscan contact. (The Merced is apparently faulting down so as to obscure the original contact.) The Pleistocene deposits exposed in the east bank are composed of 20 feet (maximum) of sand and gravel with Merced and Franciscan detritus, which rests on a truncated surface of basal beds of the Merced and is overlain by reddish-brown sands in which the bedding planes are horizontal but obscure. One may trace the Pleistocene beds some 50 feet around the north end of the cut. Here they can be seen to pass abruptly into a boulder agglomerate of basal Merced detritus. Brush and topsoil prevent further observations. Such is the extremely local extent of the terrestrial Pleistocene at Mussel Rock.

The gray basal Merced exposed in the cut is abundantly fossiliferous and dips steeply northeastward, as does the Merced north of the landslide. The overlying Pleistocene dips about 30° northeastward. Fossiliferous cobbles and pebbles lithologically and paleontologically identical with the underlying

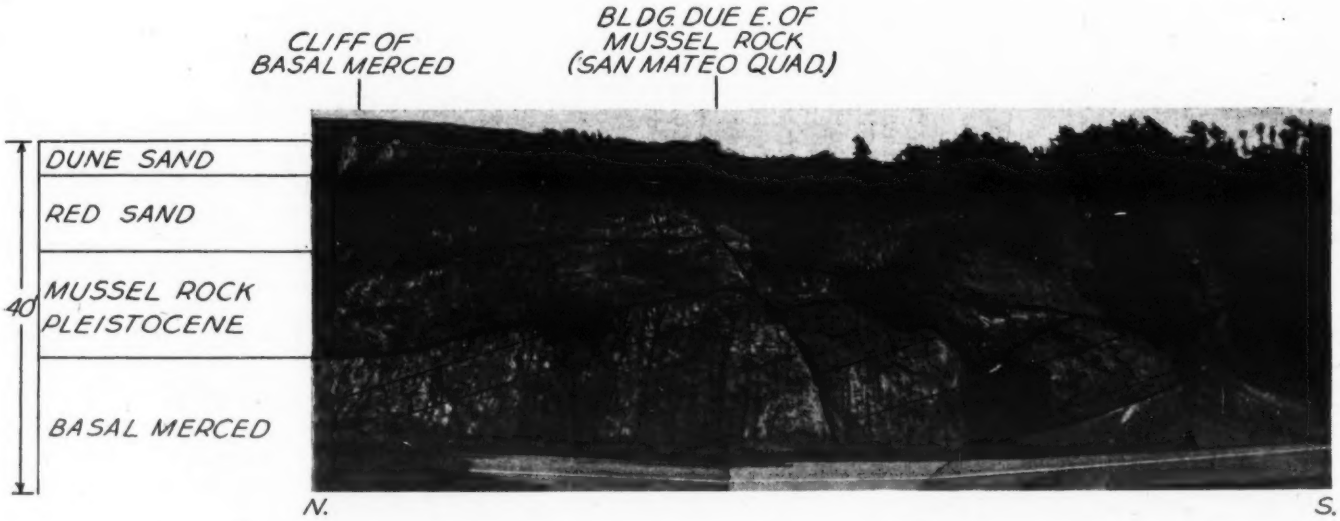

FIG. 1—Geologic section exposed on the east bank of the roadcut near Mussel Rock. A and B indicate the places in the Pleistocene beds where the majority of identifiable specimens were found. Note that a thin remnant of the Pleistocene beds is exposed to the right of the side.

Merced are numerous at the base. There is a gradation upward into gray sands and gravel containing numerous rounded Franciscan pebbles and frequently "gastropod pebbles" derived from the Merced. Clay sands follow and form the upper half of the beds. The present dip of the strata may not be the original one. The manner in which the basal cobbles veneer the eroded surface of the Merced suggests that a definite tilting to northeastward took place prior to the deposition of the overlying reddish-brown sands.

The character of the Pleistocene beds would indicate that they were deposited in a small stream flowing westward into the ocean through a valley in which exposures of basal Merced were either undercut or otherwise had slid down to be deposited along with water-worn detritus, also from the basal Merced. Quantities of water-worn fragments of bone indicate considerable transportation, but most of the identifiable specimens show little if any wear.

The gray color of the Pleistocene contrasts well with the overlying reddish-brown sands. These sands are lithologically identical with exposures of horizontal beds of the Terrace formation occurring around Lake Merced and elsewhere on the peninsula and like them clearly antedate the gray dune sand. The reddish-brown sand apparently filled in rapidly a shallow ravine in the pre-Terrace topography. At the present time a spring seep issues from the sands in the bottom of the pre-Terrace ravine; saturation of the sands at this point causes them to slide out on the highway. This fact indicates that the pre-Terrace ravine probably drained westward. About 5 feet of light-gray dune sand overlies the red sand. The dune has been static long enough to develop a veneer of loam, which supports a chaparral cover. Several small slip faults evident in the roadcut are indicative of movement of the landslide if not of movement at the Merced-Franciscan contact.

The occurrence at Mussel Rock of upper Pleistocene beds composed of basal Merced detritus is interesting inasmuch as the type section of the Merced can be shown to extend from Pliocene into Pleistocene time (Martin 1916); how far is not certain. This means that geomorphic events proceeded so rapidly, at least at the San Andreas rift, that the base of the Merced was exposed to erosion already by the late Pleistocene, hence not long after the close of Merced deposition.

Although Lawson (1914) placed the predune reddish-brown sands in the post-Pleistocene, he did so apparently on structural evidence alone. The fossil evidence from Mussel Rock is corroborative, and as far as known by the writer Mussel Rock is the only locality that furnishes paleontologic evidence.

FAUNA

The vertebrate fossils from Mussel Rock occur chiefly in the sand and gravel; there are none in the cobbles near the base of the beds.

Freshly exhumed bones are brown and soft, but those that are weathered out appear white and are much harder. The larger specimens are crushed badly, presumably by movement of the surrounding unconsolidated sediments. The spongiosa is badly rotted. Teeth, however, are in good condition. Many unrecognizable fragments are badly waterworn. The larger bones are found imbedded in sand or clayey sand as a rule, whereas the isolated teeth and smaller bones come from beds bearing many Franciscan pebbles. Several of the larger specimens were surrounded by a concentric zone of reddish iron oxide. In at least one instance a hard crust of sand cemented by iron oxides had formed on the bone itself. Collections made over the years from 1936 to 1942 indicate that the fossil contents of this exposure have been nearly exhausted. Many specimens were destroyed or buried anew by the construction of the highway through the cut.

The following list contains the identifiable bones and teeth of fossil vertebrates from the Mussel Rock locality. All specimens are catalogued in the collections of the Museum of Paleontology of the University of California at Berkeley. On the whole this assemblage is nearer to the Rodeo, McKittrick and Rancho La Brea faunas than to the older Pleistocene faunas from Irvington and Bautista.

Ground sloth (*Paramylodon harlani*).
Skull: left zygomatic arch; posterior part of right palatine; first inferior tooth; fragments of other teeth.

Postcranial skeleton: right femur, crushed but complete except for head; part of shaft of left femur; isolated head of femur; anterior cervical, costal and lumbar vertebrae incomplete; rib; dermal ossicle.

Elephant (*Elephas* sp.).
Fragments of molars and tusks; costal vertebra, lacking the spine.

Camel (*Camelops* sp.).
Molar tooth, M^2 (rt.).

Bison (*Bison* sp.).
Skull: lower jaw with cheek teeth, lacking anterior end; cheek teeth, two M^1 (rt. and left), one P^2; fragments of other teeth including an incisor.
Postcranial skeleton: innominate bone, parts of the ilium and ischium, including parts of acetabulum; cervical and first sacral vertebra.

Horse (*Equus* sp.).
Five upper cheek teeth; fragment of costal vertebra.

Bird (*Uria aalge*, murre).
Distal half of humerus.

Bird, not identified.
Fragment of shaft of limb bone.

The writer has found no other comparable Pleistocene beds in the surrounding area. However, deflated remains of gravel beds do occur on the top of the Merced cliffs to the northeast. An epiphysis of a femur of *Bison* found at the base of the cliffs on State Highway No. 1 after a heavy rain presumably came from these remnants.

The presence of the murre, a typical sea bird, indicates that the mammals lived in close proximity to the Pacific shore. The presence of typical grazing mammals of large size indicates that ample grassland pasturage existed in the vicinity.

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SILURIAN FOSSILS FROM RIPOGENUS DAM, MAINE

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ABSTRACT—At the request of Dr. Lloyd W. Fisher of Bates College, the author identified a collection of Silurian fossils made by Dr. Fisher and Mr. Alan Sawyer. The material came from Ripogenus Dam in north-central Maine at the southern end of Chesuncook Lake. The fossils occur in limestone of the Ripogenus series. Rocks of the Silurian system border the southern part of Chesuncook Lake. The fauna is dominated by corals, brachiopods and trilobites. It bears a remarkable similarity to the Niagaran of western New York, and Clinton elements are present.

INTRODUCTION

KNOWLEDGE of the geology of Maine is spotty. Some areas are known in great detail, but by far the larger part of the State has been subjected to little more than reconnaissance surveys. Most of the northern half of Maine suffers from lack of thorough geologic work. This condition may be attributed to several causes, perhaps the most prominent of which is the difficulty of the terrain with its glacial deposits and large stretches of wilderness. The absence of appreciable amounts of workable mineral deposits removes a common incentive for investigation. Because of the dearth of data, any information, however trifling it may appear, regarding the geology of Maine is worth recording. The present account discusses the presence of a Silurian fauna from north-central Maine. The identification of these fossils throws light upon the age and correlation of the Silurian of the State and has possible bearing upon paleogeographic relations. The writer wishes to express his gratitude to Dr. Lloyd W. Fisher of Bates College, Lewiston, Maine, for the opportunity to study this material.

SILURIAN OF MAINE

Keith's (1933) geological map of Maine indicates that roughly 50 per cent of the surface formations of the State are of Silurian age. Chiefly the system occupies the northern half of Maine with extensions into the central, western and southwestern portions. Outliers have been recorded in the Penobscot Bay region, along the central part of the coast, and near Eastport, at the extreme eastern end of the coast. The recent investigations of Fisher (1941) indicate that at least part of the metamorphics of the southeastern portion are of Silurian age. The general description of the Silurian given on the State map is as follows:

> Black, gray, and red slates, thin grey sandstone and quartzite layers, massive argillite; limestone beds in upper part.

The rocks trend northeast and southwest following the axes of folds. Cambrian and Ordovician formations are exposed along the anticlines, while the synclines contain areas of Devonian strata. Basic and acid intrusives cut the sediments at several localities.

Silurian fossils have been recorded from a few places in Maine. In Aroostook County studies were made in the eighties (Bailey and McInnes, 1888) of fossils found particularly in the valley of the Aroostook River, especially near Ashland and Square Lake. The faunal list published indicates that the rocks are of late Silurian age. A possible equivalent of the Niagaran of New York was reported farther east, in Canada. Silurian graptolites have been discovered and recorded by Perkins and Ruedemann (1925) and Perkins and Smith (1925) in the Waterville shales along the Kennebec River in south-central Maine. In this region the evidence points to the Clinton age of the shales. Perkins (1925) furthermore noted fossiliferous Silurian sediments from the Moosehead Lake region. These also appear to be of Clinton age. Other localities of less importance have been mentioned, but two outstanding contributions should be more fully cited. The first of these is on the Penobscot Bay region of the central coastal area (Smith, Bastin, and Brown, 1907). In this report, C. E. Beecher recorded his study of a rather large Silurian fauna and pointed out the close similarity of the fauna to the Niagaran plus certain Clinton elements of

New York. Beecher's list is quoted as follows:

Graptolites

Monograptus clintonensis Hall

Corals

Streptelasma calyculum Hall
Chonophyllum niagarense Hall
Favosites venustus Hall
F. niagarensis Hall
F. favosus Hall
Coenites ramulosus Hall
Halysites catenulatus Linnaeus
Heliolites spinoporus Hall

Crinoids

Ichthycrinus laevis Conrad
Eucalyptocrinus caelatus Hall

Tribolites

Encrinurus punctatus Foerste
Calymene niagarensis Hall
Homalonotus delphinocephalus Green
Dalmanites limulurus Green
Ceraurus niagarensis Hall
Illaenus ioxus Hall
Proetus stokesi Hall

Brachiopods

Lingula lamellosa Hall
Orthis elegantula Dalman
O. hybrida Sowerby
Plectambonites transversalis Wahlenberg
P. (cf.) *sericea* Sowerby
Leptaena rhomboidalis Wilckens
Stropheodonta profunda Hall
Orthothetes subplanus Conrad
Pentamerus occidentalis Hall
Chonetes cornutus Hall
Whitfieldella nitida Hall
Nucleospira pisum Hall
Atrypina disparilis Hall
Spirifer crispus Hisinger
S. sulcatus Hisinger
S. radiatus Sowerby
Cyrtina pyramidalis Hall
Atrypa reticularis Linnaeus
A. nodostriata Hall
Rhynchonella neglecta Hall
R. obtusiplicata Hall

Pelecypods

Avicula demissa Conrad

Gastropods

Platyostoma niagarense Hall

Cephalopods

Orthoceras annulatum Sowerby
O. subcancellatum Hall
O. virgulatum Hall
Cytoceras subcancellatum Hall

Nearly all the corals are confined to the lower beds, [being found in] a conglomerate of coral fragments together with pebbles of quartz and hydromica schist, [and in] a limestone. The greatest number of species is found near the middle of the series [on the shore northeast of Ames Knob] in a slightly indurated shale. The fauna was evidently a rich one, and several of the unidentified species are probably new to science.

FIG. 1—Outline map of Maine showing location of Ripogenus Dam and other localities mentioned in this account.

H. S. Williams (Bastin and Williams, 1914) studied extensive collections from the Eastport region in Washington County and published lists of fossils from a number of stratigraphic units of Silurian age. His lists of formations of Niagaran age follow:

DISTRIBUTION OF SPECIES IN THE SILURIAN FORMATIONS IN THE EASTPORT QUADRANGLE

(List is in stratigraphic order, youngest at top.)

Dennys formation

Beyrichia cf. *maccoyiana* Jones
B. spinulosa Boll var.
Bilobites bilobus (Linnaeus)
Bollia cf. *bicollina* Jones
Cytherella concinna Jones
C. coicinna var. *ovalis* Jones

STRATIGRAPHIC OCCURRENCE OF FOSSILS IN THE CHESUNCOOK LIMESTONE

	Medinan	Niagaran	Lockport	Guelph	Clinton	Rochester	Cayugan
Coelenterata.							
Stromatoporoidea ? undet.		×					×
Zaphrentis turbinata (Hall)			×				
Diphyphyllum caespitosum Hall ?			×	×			
Favosites favosus (Goldfuss)		×	×	×	×		
F. niagarensis Hall			×				
Halysites catenularia (Linnaeus)		×					×
Heliolites elegans Hall			×				
Corals, undetermined							
Brachiopoda.							
Rhipidomella hybrida (Sowerby)?		×					
Pentamerus oblongus Sowerby		×					
Atrypa reticularis (Linnaeus)		×					×
Whitfieldella nitida (Hall)			×				
W. cf. *edmondsi* Williams							×
Brachiopoda, undetermined							
Pelecypoda.							
Modiolopsis leightoni Williams							×
Gastropoda.							
Hormotoma sp. undet.							
Poleumita crenulata (Whiteaves)		×		×		×	
P. scamnata Clarke and Ruedemann		×		×		×	
Gastropod, undet., suggests *Oxydiscus* of L. Devonian							
Gastropoda, undetermined							
Arthropoda.							
Bumastus (*Illaenus*) *ioxus* (Hall)		×	×			×	
Calymene niagarensis Hall		×	×			×	×
Dalmanites limulurus (Green)		×	×		×	×	

Dalmanites longicaudatus Murchison
Leptaena laevigata (Sowerby)
L. minima var. *grayii* Davidson
Lingula oblata Hall
Orthis equivalis Davidson
Plectambonites transversalis (Wahlenberg)
Skenidium lewisi Davidson
Spirifer crispus (Hisinger)
Streptelasma calicula Hall

Quoddy shale

Anoplotheca barrandei (Davidson)
Atrypa reticularis Linnaeus
Dalmanella elegantula (Dalman)
Leptaena rhomboidalis (Wilckens)
Schuchertella subplana (Conrad)
Pentamerus cf. *oblongus* Sowerby
Plectambonites transversalis (Wahlenberg)
Spirifer radiatus Sowerby
S. crispus (Hisinger)

Williams's conclusion was that these older beds represent the Niagaran of New York and the Wenlock of England. Higher beds were assigned to the Cayugan.

RIPOGENUS SERIES

The Ripogenus series of Maine was named and first described by Toppan (1932). He states:

The Ripogenus series which has a total thickness of perhaps 2000 feet overlies an igneous rock of gabbroid nature, the contact being apparently intrusive.

The basal member of the formation consists of coarse grit which in the hand specimen is a plum-colored rock the shaly matrix of which contains pebbles of red and of white quartz. The thickness of this grit is about 15 feet.

Conformably overlying the basal grit is a sandy limestone that has a thickness of nearly 50 feet. In the hand specimen this rock is seen to be a rather sandy limestone of light-gray color which weathers to a buff shade. It is abundantly fossiliferous, the fossils being especially prominent on the weathered surfaces. Specimens of this fossiliferous limestone were submitted to Miss Winifred Goldring, Associate Paleontologist of the New York State Museum, who pronounced their fauna to be of middle Silurian (Niagara)

FIG. 2—Exposure of Chesuncook limestone above Ripogenus Dam. Photograph by L. W. Fisher.

age. This conclusion was reached by Dr. Rudolf Ruedemann also upon viewing them. Among the species present were a *Pentamerus*, similar to *P. oblongus*, an *Illaenus* and an *Anastrophia*. The preponderance of stromatoporids suggests reef conditions according to Miss Goldring. Interbedded with the limestone is a greenish banded quartzite a few feet in thickness.

Conformably overlying the limestone is a clean white quartzite about 50 feet thick; this is in turn overlain by a monotonous series of gray-green quartzites which make up the rest of the section.

The Ripogenus series takes its name from Ripogenus Dam, situated in Piscataquis County at the south end of the southeast arm of Chesuncook Lake (see figure 1). The lake, which is in north-central Maine, is crossed by the forty-sixth parallel. It lies about 69°30′ west longitude and is some 20 miles northeast of Moosehead Lake. The sediments at the dam are in contact with igneous intrusions. About four years ago, Dr. Lloyd W. Fisher of Bates College, Lewiston, Maine, submitted to the writer a collection of fossils from the Ripogenus series at the dam. The material had been collected by Alan Sawyer and the geology mapped by Lloyd W. Fisher.

As the author has not been near the locality since a boy, his first-hand knowledge is nil. In a letter of June 3, 1941, Fisher described the locality of the rocks of the Ripogenus series. He stated:

> We are splitting them up into the Chesuncook limestone and the Ripogenus volcanics for the simple reason that according to hunters and fishermen the limestone is found all along the lake shore. The volcanics seem to be more or less locally developed around the dam.

He stated also, that the limestones dip northwesterly and strike northeasterly. Igneous intrusions are present associated with the sedimentaries. The fossiliferous limestone is exposed in a cliff about 50 feet high; the total thickness of beds seen is about 350 feet. The fossils have been studied and the following faunal list is the result:

INTERPRETATION

The Silurian fauna from the Chesuncook limestone of the Ripogenus series is remarkable for two reasons in particular. First, there appear to be no new species present. Second with the exception of two of the identified species, *Whitfieldella edmondsi* and

Modiolopsis leightoni, all are well-known New York Silurian fossils. The age of the fauna is indicated in the table; it is predominately Niagaran with certain Cayugan elements added. In this it is reminiscent of the fauna from the Penobscot Bay region already quoted. It is distinctly different from the Eastport fossils but shows a certain affinity in the aforementioned coexisting species, *Whitfieldella edmondsi* and *Modiolopsis leightoni*. These two exceptions were originally described by Williams from beds in the Eastport area. He thought them more likely to be of very early Cayugan, rather than Niagaran age. Toppan (1932) has suggested the probable relations between Maine and New York in Niagaran times. The Ripogenus fauna seems to fit the picture and possibly throws more specific light upon this matter. While it is possible or even probable that a seaway connected Maine with western New York by way of Quebec, the similarity between the Ripogenus and Penobscot Bay faunas may indicate an additional connection south and west.

CONCLUSIONS

From the study of the Silurian fossils from the Chesuncook limestone of the Ripogenus series of north-central Maine, it is concluded, first, that the fauna is dominated by fossils belonging to the Niagaran of New York State. Clinton elements are included. The distinct difference between the Ripogenus fossils and those of Washington County in the extreme southeastern corner of Maine, indicates that these two regions may have been discrete or that their respective biotas existed in the same sea but under dissimilar environments.

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JOURNAL OF PALEONTOLOGY, VOL. 19, NO. 1, PP. 69–71, 2 TEXT FIGS., JANUARY 1945

THE THORAX OF TERATASPIS

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ABSTRACT—The most important corrections involved in a new restoration of the Onondagan trilobite *Terataspis* are in the pleura, which have been discovered to terminate in long tubular tapering spines. The pleural lobes exclusive of the spines are narrower than previously supposed, hence the entire thorax is narrower, and the posterior margin of the cephalon and the anterior margin of the pygidium are similarly more narrow.

IN 1941 the writer (Reimann, 1941) described a restoration of *Terataspis* which was based upon the fragmentary material in the collection of the Buffalo Museum of Science. Notably lacking in this and in the other collections seen were uncrushed, unweathered thoracic segments. Consequently in preparing the restoration the segments were represented in a rather conventional form. The subsequent find (Reimann, 1943) of an almost entire specimen of this genus in the Onondaga limestone at the Fogelsanger Quarry near Williamsville, N. Y. proved that the pleural lobes were erroneously represented. This and other features necessitate revisions of earlier descriptions and restorations. The new specimen shows the underside of the test of a trilobite with a total length, as preserved, of 13 inches. Approximately the right half of the trilobite (left half of the specimen) is missing having been broken and lost in quarrying operations. Somewhat less than half of the cephalon is preserved. It is tipped forward so far that some of the dorsal surface is exposed and the cranidium has been crushed. The free cheek is also tipped. Part of the hypostoma and epistoma are present in their proper position. The thoracic segments are mostly tipped forward, although the first four are in a nearly natural position. While most of the thorarachis was preserved, it is crushed. Some of the annulations were accidentally destroyed in exploratory chipping, others were deliberately removed in order to better expose the surface of an adjoining one. More than half of the pygidium is present.

The width of each pleural lobe is shown by the new find to be about half the width of the thororachis. The posterior portion of each pleural annulation is extended, however, into a tapering, spiniferous, gently retrally curved tubular spine of the same length as the pleural annulation which bears it. Thus the total width of the pleural lobe including the spines is about equal to the width of the thororachis. The pleural lobes widen slightly posteriorally, but even in the recently found specimen it is not certain whether or not the thororachis widens similarly.

Each annulation of the thororachis bears about six conspicuous spines in addition to the scattered small spines. Of these, the axial pair are the largest, with the others diminishing in size toward the pleura. At the outer margin of each pleural annulation, just above the base of the large terminal spine and posterior to the outer end of the pleural groove, is a short, stout spine directed outward and upward. Two additional but smaller vertical spines, diminish in size toward the axial furrow. The posterior border of the first several terminal pleural spines show comparatively prominent spines, reflecting the pattern of the posterior border of the free cheek and genal spine. All of the terminal spines may be similarly ornamented but the specimen at hand is so preserved that this is not certain.

The narrower thorax in contrast to our earlier conception (Reimann, 1931) enabled the remodelling of the cephalon and pygidium to conform more closely to the evidence presented by the actual specimens of those parts. In the 1941 restoration, in order that the cephalon and pygidium fit the supposed width of the thorax, it was necessary to widen their articulating edges unnaturally, producing some distortion of their proportions. The new restoration (fig. 1) shows the shortened articulating edges. The effect of this on the cephalon is shown in the proportionally longer genal spine, the shorter lateral lobes, and the more longitudinally directed posterior part of the facial suture.

Narrowing the anterior of the pygidium

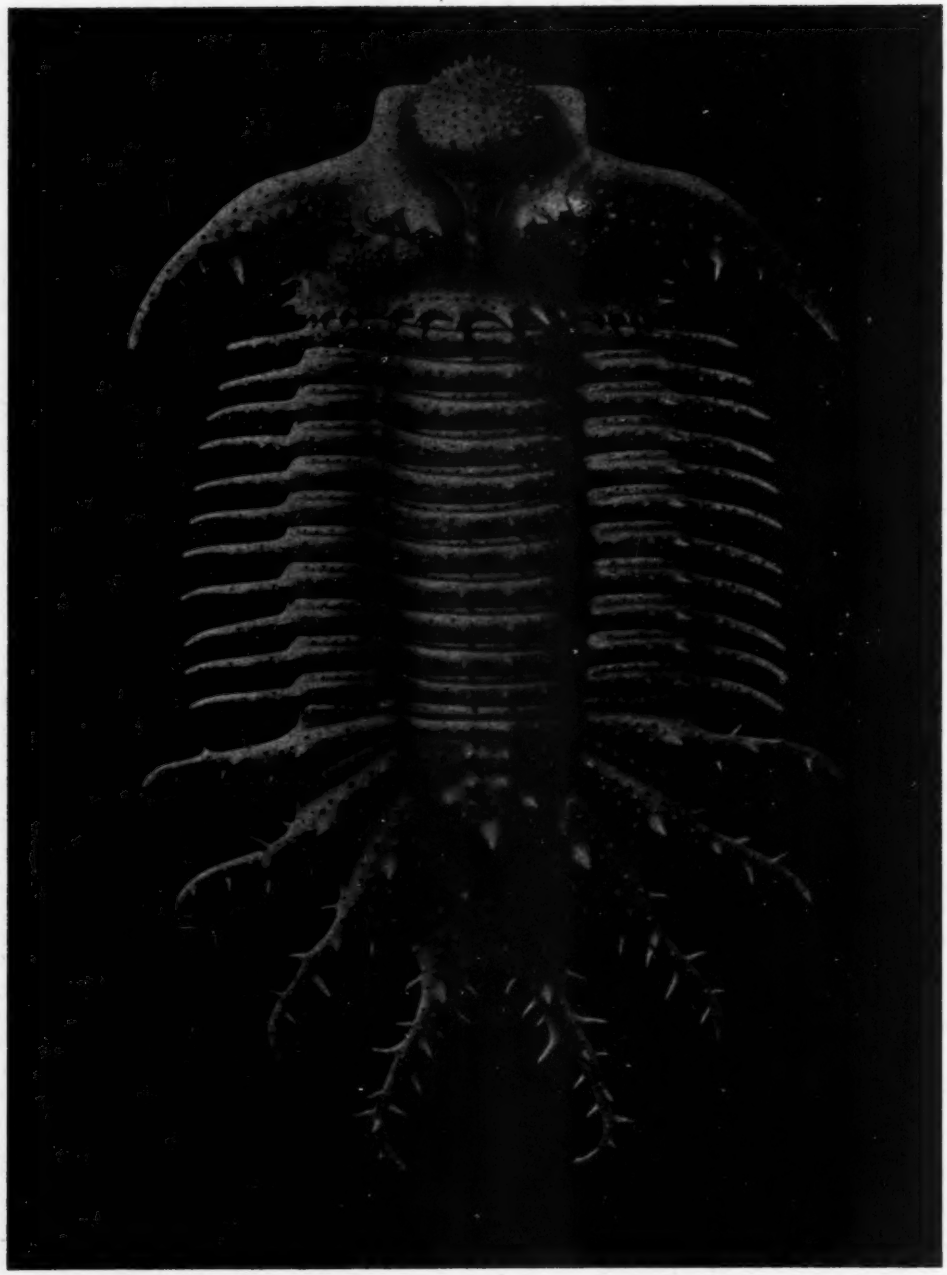

FIG. 1—*Terataspis* sp. Restoration, ×½, based on Buffalo Museum of Science no. E 15874.

brings its proportions into more harmonious agreement with the actual specimens under study. The fourth pleural ribs are shown to be almost obsolescent with the spines greatly diminished in size. Near the distal end the first two ribs bear a large outward-inclined, nearly vertical spine. The third bears a similar spine near its center. A conspicuous

spinose fold divides the furrow between the first and second ribs. A less abrupt fold occurs in the furrow between the third and fourth ribs. The pygorachis extends only about half the length of the pygidium, bears four transverse furrows, and terminates in a large, erect, posteriorly inclined spine. The furrows become shallower and wider posteriorly until the fourth is scarcely apparent. Four stout spines are borne by the third annulation arranged in an arc anterior to the single larger spine of the fourth annulation. The first two annulations each have two stout spines near their center, diminishing in size anteriorly.

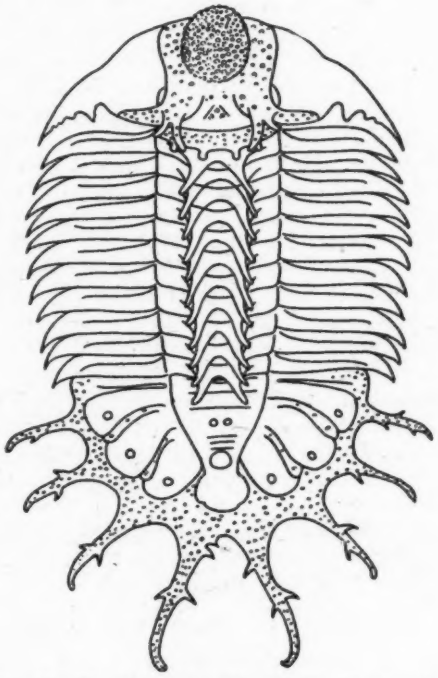

FIG. 2—*Terataspis grandis* (Hall). Restoration by Clarke (1892).

The entire dorsal surface of the test is covered with small spines except for the grooves, where they are absent. They are less thickly studded than indicated in my previous restoration. The ventral surface of the terminal pleural spines shows a pattern of imbricating lines similar to those of the cephalic and pygidial doublures.

The inference (Reimann, 1941) that *Terataspis* lacked the enormous divergent axial spines on the thorax shown in the earliest restorations (Clarke, 1892) (fig. 2) is proved to be correct by the evidence of the nearly articulated specimen which is the basis for these notes.

It may be noticed that reference has not been made in this paper to a specific name for this trilobite. There is some evidence (Billings, 1874) that more than one species is included in the genus *Terataspis* and additional study and comparison of material is considered necessary before any specific name can be safely assigned to the Onondagan species.

Acknowledgement is made to Mr. Paul Marchand, Preparator, Buffalo Museum of Science for his excellent work in producing the wax model illustrated herewith, and to Mr. Charles E. Simmons, Photographer in Charge, for the photograph.

The hypotype is no. E 15874 in the paleontological collections of the Buffalo Museum of Science.

MANUSCRIPT RECEIVED OCTOBER 4, 1943.

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A NEW UPPER CRETACEOUS OYSTER FROM DEEP WELLS IN MISSISSIPPI

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SETS OF core samples from deep wells in the Heidelberg oil field, Jasper County, Mississippi and in the Eucutta Field, Wayne County, Mississippi, recently submitted to the United States Geological Survey by Mr. Roy T. Hazzard, District Geologist for the Gulf Refining Company of Louisiana, have yielded several species of macroscopic fossils having positive value in correlation. Among them is a new oyster, which, because of its presence in cores from seven wells in the Heidelberg Field and one, or questionably two, wells in the Eucutta Field, appears to be a useful index fossil and should, therefore, start its career as a horizon marker with a proper legal christening. The name here proposed is *Ostrea oleana*, derived from the Latin *oleum*, oil, and *-anus*, associated with. This name is chosen because the shells are found in more or less glauconitic sands and sandstones, part of which are saturated with oil. The shells are numerous in some of the cores.

In addition to the shells of *Ostrea oleana* found in well cores from the two oil fields several shells of this species were identified from a well in Jones County, and several specimens from a well in Hinds County were furnished by Mr. Grover E. Murray, Jr., geologist for the Magnolia Petroleum Company. The latter occurrence indicates a geographic west-northwest range from the Eucutta Field of at least 100 miles.

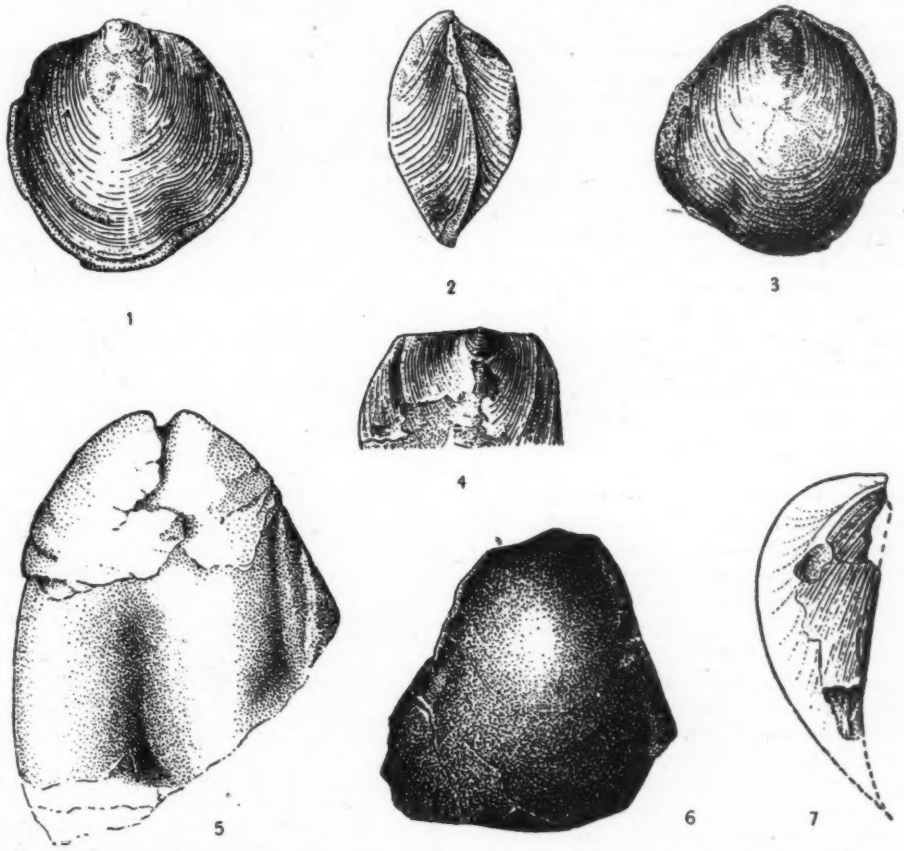
Although *Ostrea oleana* is a new species known only from the subsurface in Mississippi, and therefore having no value in determining the age of its containing strata, with respect to formations at the surface in other parts of the Gulf region, other fossils more or less closely associated with it in the well cores indicate that the subsurface strata correspond in age to the lower part of the Austin chalk. Perhaps the most diagnostic of these associated species is *Gryphaea aucella* Roemer, which occurs in beds just above the zone bearing this oyster but is of less common occurrence. An important species identified in one core sample from a a depth of about 5252 feet in Gulf Refining Company Rowell No. 1 well (Heidelberg Field) is *Inoceramus undulatoplicatus* Roemer, which in Texas is restricted in vertical range to a narrow zone a little above the middle of the Austin chalk. Another species of *Inoceramus* found at a depth of about 5055 feet in Gulf Refining Company Green No. 1 well (Eucutta Field), though badly crushed, is obviously related to *Inoceramus umbonatus* Meek and Hayden, a species recorded from the Niobrara chalk (of Austin age) in the Western Interior.

The maximum observed vertical range of *Ostrea oleana* is about 160 feet in the Gulf Refining Company Gus Husband No. 1 well (Heidelberg Field). The lowest occurrence recorded, at a depth of 5569 feet in Gulf-Hamill Rowell No. 1 well (Heidelberg Field) is less than 20 feet above a core containing *Ostrea alifera* Cragin (variety), an Eagle Ford species. If correctly interpreted the contact between beds of Eagle Ford and Austin age in this well lies between depths of 5569 and 5577 feet. The detailed distribution of *Ostrea oleana* in the wells studied is given on a subsequent page.

OSTREA OLEANA Stephenson, n. sp.
Figures 1–7

Shell of medium size, thick in the dorsal region, thinning to a knife edge at the ventral margin, elongated in the direction of the height in adults, slightly inequivalve. The beaks are small, nonprominent, and unequal, the left one rising slightly above the right one; they are located a little in advance of the midlength in most shells. Both valves are moderately inflated well up toward the umbonal region. The surface of the right valve rounds over rather steeply from the point of maximum inflation to the dorsal margin above. In profile viewed edgewise this valve presents a smooth continuous asymmetrical curve from the beak to the ventral margin, the strongest curvature being well above the midheight. The corresponding profile of the left valve is less strongly and more evenly curved; viewed from the front the ventral part of the shell is

bent rather strongly to the right (to the left if viewed from the rear). The dorsal margin varies in different individuals from nearly straight to gently arched, and meets the anterior and posterior margins at obtuse angles; the dorsal margin of the right valve is more nearly straight than that of the left valve; the anterior and posterior margins diverge ventrally to such a degree that the dimension of the lower part of the shell is about twice as great in the direction of the length as the upper part; the ventral margin is rather strongly curved. The margins of the right valve are overlapped by the left valve to a maximum of 3 mm. In some young individuals the surface adjacent to the upper anterior and posterior corners of the shell broadens and flattens out slightly, suggesting incipient earlike extensions, but this is a variable feature on different individuals and may not be present. The inflation of the left valve tends to form a broadly rounded radial ridge with broad, shallow radial depressions on either side expanding into broader radial flutings or waves in the ventral region of adult shells; these features are also variable



FIGS. *1–7—Ostrea oleana* Stephenson, n. sp. *1*, Left valve of a half-grown individual (U.S.N.M. No. 103739; U.S.G.S. Coll. 19217). *2*, Rear view of the same shell. *3*, Right valve of the same shell showing also the overlapping margin of the left valve. *4*, The upper or dorsal portion of an incomplete right valve showing the fine lines of growth and the subangular anterodorsal and posterodorsal corners (U.S.N.M. No. 103740); U.S.G.S. Coll. 19268. *5*, Exterior view of the posterior and posteroventral portion of a large incomplete left valve and internal mold, showing the coarse fluting of an adult shell (U.S.N.M. No. 103741; U.S.G.S. Coll. 19287). *6*, Exterior view of the holotype, a right valve, the surface layers of which were peeled off when the shell was separated from the matrix (U.S.N.M. No. 103742; U.S.G.S. Coll. 19217). *7*, Front edge view of the holotype, an adult shell, showing the thick shell of the dorsal portion, and the strong bend to the right of the ventral portion.

in different individuals. As preserved the surface of most shells is either peeled off or rather badly corroded; occasional patches, however, show rather fine concentric growth lines, and some shells present small, weak radial lines and ridges in the umbonal region.

The nearly complete young shell shown in figures 1–3 measures: length, 33 mm., height, 33 mm., thickness, 18 mm. The largest adult shell that is complete enough to measure is about 50 mm. long, 60 mm. high, and 32 mm. thick.

In the adult the area is broad, corresponding in breadth to the thickness of the shell along the nearly straight dorsal margin; the area is marked by the numerous parallel lines of growth. The ligament is set centrally in the area in a broad, shallow pit. The adductor scars and other internal features are not well exposed in the available material.

The previously described species most nearly related to *Ostrea oleana* is *O. battensis* Stephenson (1936b) from the upper part of the Tombigbee sand member of the Eutaw formation in central and eastern Alabama. *O. battensis* was originally described under the preoccupied name *O. johnsoni* Stephenson (1936a). The new species is analogous in size and general aspect to *O. battensis*, but differs in that the adult shell is consistently curved strongly to the left as viewed from the rear, and its surface when not destroyed by peeling or corrosion is characterized by more delicate concentric lining; radial lining if present at all is obscure and delicate.

Types.—With the exception of one paratype, a young shell, shown in figures 1–3, the numerous shells recovered from the cores are incompletely and imperfeetly preserved. The adult right valve pictured in figures 6, 7, though very incomplete, is chosen as holotype because it shows the characteristic curvature which is the main distinguishing feature of the species.

Holotype, U.S.N.M. No. 103742, one figured paratype, U.S.N.M. No. 103739, and 14 unfigured paratypes, U.S.N.M. No. 103743; these are from the locality of the holotype. One figured paratype, U.S.N.M. No. 103740, and one figured paratype, U.S.N.M. No. 103741.

Distribution.—The species has been identified from wells in Mississippi as indicated below; the collection numbers refer to the collections of the United States Geological Survey.

Eucutta Field, Gulf Refining Company, G. S. Stanley No. 8, NW¼ NE¼ sec. 1, T. 9 N., R. 9 W., Wayne County, depth 5145 feet. Locality of holotype and 16 paratypes, two figured (coll. 19217); ? depth 5155 feet (coll. 19218); ? depth 5166–6168 feet (coll. 19219).

?Eucutta Field, Gulf Refining Company, questionably G. S. Stanley No. 7, SW¼ SE¼ sec. 36, T. 10 N., R. 9 W., Wayne County, depth 5123–5143 feet (coll. 19226).

Heidelberg Field, Gulf Refining Company, Sallie E. Dantzler No. 1, NE¼ SE¼ sec. 31, T. 1 N., R. 13 E., Jasper County, at depths, 4895–4970 feet (colls. 19237, 19239–19242); 5007–5009 feet (colls. 19243, 19244).

Heidelberg Field, Gulf Refining Company, Helen Morrison No. 1, SW¼ SE¼ sec. 30, T. 1 N., R. 13 E. Jasper County, at depth 4917–4936 feet (coll. 19255).

Heidelberg Field, Gulf Refining Company, Lewis-Morrison Unit No. 1, NE¼ SE¼ sec. 30, T. 1 N., R. 13 E., Jasper County, at depths 4555–4570 feet (colls. 19261, 19262, 19264); 4608–4615 feet (colls. 19266, 19267); 4615–4635 feet (coll. 19268, includes one figured paratype); 4635–4655 feet (coll. 19269), 4655–4675 feet (colls. 19270–19273).

Heidelberg Field, Gulf-Hamill, Rowell No. 1, NW¼ NE¼ sec. 30, T. 1 N., R. 10 W., Jasper County, at depths 5469–5489 feet (coll. 19299); 5492–5512 feet (colls. 19300, 19301); 5518 (coll. 19303); 5532 feet (coll. 19304); 5569 feet (coll. 19305).

Heidelberg Field, Gulf Refining Company, Gus Husband No. 1, NW¼ SE¼ sec. 25, T. 1 N., R. 12 E., Jasper County, at depths 5349–5369 feet (coll. 19248) and 5520 feet (coll. 19251).

Heidelberg Field, Gulf Refining Company, J. Morgan No. 1, SW¼ SW¼ sec. 35, T. 1 N., R. 12 E., Jasper County, depth 5063 feet (coll. 19287 includes 1 figured paratype).

Heidelberg Field, Gulf Refining Company, J. Morgan No. 2, SW¼ SW¼ sec. 34, T. 1 N., R. 12 E., Jasper County at depths 5108 (coll. 19329); 5158 feet (coll. 19330); 5165–5185 feet (colls., 19331–19335); 5205–5218 feet (colls. 19337, 19338).

Gulf Refining Company, Masonite No. C-1 well, sec. 15, T. 9 N., R. 10 W., Jones County, at depths 5446–5466 feet (colls. 19318, 19319); 5486–5496 feet (coll. 19321).

J. V. Canterbury, No. 1 J. R. Ball, NW¼ SE¼ sec. 7, T. 5 N., R. 1 W., Hinds County, depth 4573–4590 feet (coll. 19353).

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PALEONTOLOGICAL NOTES

DIMENSIONS, WHORLS, AND CHAMBER COUNTS IN THE FORAMINIFERAL FAMILY CAMERINIDAE

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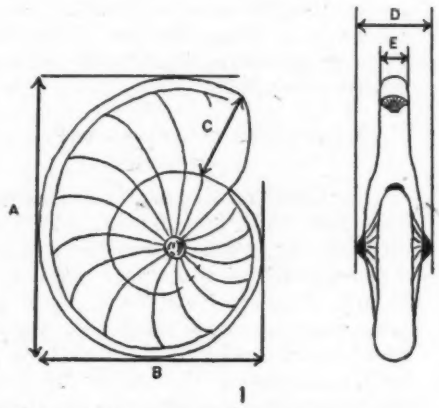
THE PURPOSE of this note is to suggest a standard way of measuring specimens of the foraminiferal family Camerinidae and a method of counting whorls and chambers. The terminology has been discussed with Dr. T. Wayland Vaughan, of the U. S. National Museum, and conforms to his usage.

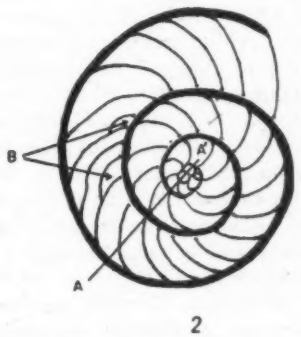
Proportions, number of whorls, and number of chambers per whorl are among the more important morphological characters that distinguish species within the family. The numerical expression of these characters however, requires consistent methods of counting and measuring in order to reduce error and give comparable results. Otherwise the numerical tabulation of one author might be appreciably different from that of another, even though an identical suite of specimens was measured.

The minimum number of dimensions necessary to the description of a camerinid foraminifer comprises the *greater diameter, lesser diameter, projection at aperture, thickness,* and *thickness at edge.* These are shown in figure 1, as is the orientation of the test, so no definition is needed. Other measurements may be used as the necessity arises. It is suggested that ratios be expressed in terms of the greater diameter, since that dimension is common to both median and transverse sections as well as to unsectioned specimens.



1

FIG. *1*—Diagrams of a simple camerinid foraminifer (*Operculinoides*), showing orientation of the test and terminology of dimensions. A, greater diameter; B, lesser diameter; C, projection at aperture; D, thickness; E, thickness at edge.



2

FIG. *2*—Generalized sketch of a median section of *Operculinoides*, showing 3½ whorls. A–A′, line marking end of whorls; B, aborted chambers (teratological).

Whorls are defined as ending at a line bisecting the first two chambers (embryonic apparatus in the megalospheric form) and extending to the peripheral margin (figure 2). The chamber count for the first whorl includes the initial chamber. Aborted chambers are included, even though they give an abnormally high number of chambers per whorl for the species.

NEW NAMES FOR THREE PALEOZOIC FOSSIL HOMONYMS

ROUSSEAU H. FLOWER
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The homonyms dealt with in the present note were brought to the attention of the writer by Mr. Clinton Kilfoyle, who encountered them in the revision of the catalogue of type specimens of fossils in the collections of the New York State Museum. The types of most of the species involved are in this collection. The present note is intended only to eliminate the nomenclatorial confusion caused by these homonyms.

LINGULA CLARKEI Flower, new name

This specific name is proposed to replace *Lingula elliptica* Clarke, 1907, p. 288. The name *Lingula elliptica* has been previously applied to three different species. It was first used by Phillips (1836), for a European species which the writer has not investigated Hall (1843) employed the name for a species from the Clinton beds of Walcott, N. Y. His name was changed to *Lingula subelliptica* by d'Orbigny (1850, p. 34). The name was employed by Emmons (1855) for a species from the Cambrian of Agusta County, Virginia. Schuchert (1897) retains this species in *Lingula* with doubt, and refrains from changing the name. He observed: "This species belongs to another genus. The specific name will therefore not conflict with that of Phillips." Yet the species is clearly a homonym of Phillips' species, a matter which is quite apart from the question of the proper generic designation of this species. No new name is proposed here for this form since (1) the location of the type is not known and the identity of the species is therefore doubtful; (2) the species does not seem to have been recognized by recent students of the Cambrian of the Appalachians.

Lingula clarkei rests at present upon a single specimen, which is a lectoholotype. Clarke (1907) originally figured two specimens under this name, but later (1909) removed one, the larger and more incomplete of the two, to *Lingula spathella* Hall (1859), a species originally described from the New Scotland limestone of New York. *L. clarkei* is from the Grand Grève limestone of Gaspé.

PTERINEA NYLANDERI Flower, new name

Pterinea nylanderi is proposed for *Pterinea brisa* Clarke 1907, not Hall, 1868. The species is named for Mr. Olof O. Nylander, to whose careful collecting we are indebted for most of our knowledge of the fossils of the Lower Devonian Chapman sandstone of Maine. *P. brisa* was originally used by Hall (1865) for a species from the Middle Silurian Waldron shale of Indiana. Clarke's species, a very different form, is from the Chapman sandstone of Maine. In view of this change, *P. brisa vexillum* Clarke will become *P. nylanderi vexillum*.

MODIOLOPSIS CLINTONENSIS Flower, new name

This name is proposed for *Modiolopsis ovata* Hall, 1852, not Conrad, 1841. Conrad originally proposed *Cypricardites ovata* for a pelecypod from the Upper Ordovician of Pulaski County, New York. Hall in the same year made this species a synonym of *Modiolopsis modiolaris* Conrad, 1838. Hall (1852) employed the name *Modiolopsis ovatus* for a new species from the Herkimer sandstone, of the Clinton group of the Middle Silurian. Bassler (1915) corrected the spelling to *Modiolopsis ovata* Hall. Ruedemann (1925) revived Conrad's species *ovata*, but placed it in the genus *Modiolopsis*. Therefore *Modiolopsis ovata* (Conrad, 1841) must take precedence over *Modiolopsis ovata* Hall 1852, and the new name *Modiolopsis clintonensis* is here proposed for Hall's species.

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CREPICEPHALUS EDWARDSI RAASCH, NEW NAME FOR CREPICEPHALUS OWENI RAASCH, 1943

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and
CHRISTINA LOCHMAN
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Dr. Franco Rasetti, Université Laval, has recently called our attention to the fact that the name *Crepicephalus oweni* Raasch is a homonym of *Arionellus* (*Crepicephalus*) *oweni* Meek and Hayden, 1861, later called *Crepicephalus oweni* (Meek and Hayden) by Miller, 1889, and now known as *Modocia oweni* (Meek and Hayden) Walcott, 1925.

We wish to propose the name *Crepicephalus edwardsi* Raasch for the Wisconsin species in honor of the late Dr. Ira Edwards of Wisconsin. It should also be noted that the faunule of *Crepicephalus* subzone I will be henceforth known as the *Crepicephalus edwardsi* faunule.

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SAAROLEPIS, NEW NAME FOR ANASPIS ROBERTSON, 1941

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In 1941 I described[1] a new genus and species of anaspid ostracoderm from the Upper Silurian of Oesel, giving the new genus the name *Anaspis* and the genotype *Anaspis oeselensis*. Dr. T. H. Eaton has kindly called my attention to the fact that this generic name is preoccupied by a genus of beetles, *Anaspis* Geoffrey, 1762.

It is convenient to use names with a common ending for genera in the same family or order. This has been followed in general in naming the genera of Osteostraci. Dr. Kaier, in describing three Norwegian genera of the Anaspida, used the descriptive names *Pterolepis*, *Pharyngolepis*, and *Rhyncholepis*. I am therefore proposing to substitute the new generic name *Saarolepis* (from the Estonian name for the island of Oesel) for *Anaspis* Robertson, 1941. The genotype thus becomes *Saarolepis oeselensis* (Robertson).

[1] ROBERTSON, GEORGE M., 1941, The ostracoderm order Anaspida, with description of some Upper Silurian material: Kansas Acad. Sci. Trans., vol. 44, pp. 314–317.

JOURNAL OF PALEONTOLOGY, VOL. 19, NO. 1, PP. 78–80, JANUARY 1945

SOCIETY RECORDS AND ACTIVITIES

SEMICENTENNIAL OF THE INTERNATIONAL COMMISSION ON ZOOLOGICAL NOMENCLATURE

The International Commission on Zoological Nomenclature was created by the Third International Zoological Congress, then meeting in Leyden, fifty years ago this summer. It has since become the keeper and the interpreter of the *Rules of Zoological Nomenclature*, all of which were formulated by the Commission and became effective upon adoption by the International Zoological Congresses.

The Council of the Paleontological Society takes this fitting occasion to call attention to the very welcome renaissance of the Commission and to appeal for more widespread use of its services and undivided support of its work. Perhaps many of us have come to take the International Commission for granted and to assume that world-wide adherence to its single code of rules is natural and inevitable. Of course it is not. The prestige of the Commission and the authority of the code of *Rules* have grown through the years only because of the care and intelligence employed by a succession of outstanding commissioners and because the Commission is international in character. Only regulations that would commend themselves to an overwhelming majority of zoologists the world over have been written into the *Rules;* and there is no authority to enforce them except the contemplation of thoughtful men of the chaos and confusion that would result from the lack of rules governing zoological nomenclature, or from a conflict of two or more rival codes. Any move that would weaken the prestige of the Commission or divide its authority endangers the whole structure so carefully built up during the last half century to secure uniformity and stability in zoological nomenclature.

From its inception until the summer of 1936, the Secretariat of the Commission was lodged in Washington, D. C., and Dr. C. W. Stiles served continuously as its devoted secretary. During these years the *Code of Rules* evolved to its present form, and *Opinions* to the number of 133 were published by the Commission as interpretations of the *Rules*. The expenses of the office, including clerical aid, were borne by the department of the U. S. Government of which Dr. Stiles was an officer, and the cost of publishing the *Opinions*, was then borne by the Smithsonian Institution, so that the Commission, as such, had neither income nor expenses.

Upon Dr. Stiles' retirement, Mr. Francis Hemming was elected to succeed him and the Secretariat was transferred to the British Museum (Natural History) in London. With this change the Commission found itself without funds even to transfer its extensive records and documents from Washington to London, to say nothing of publishing additional *Opinions* already formulated. In response to an appeal for funds to carry on, a modest sum was subscribed, chiefly by the museums and learned societies in London. This situation entailed months of delay before the archives were transferred to London, and the war broke over Europe before the new secretary could establish his headquarters and carefully go through the vast accumulation of matters pending action by the Commission. The activity of the Commission had declined during the last years of Dr. Stiles' office when ill health prevented him from giving the accustomed share of his devoted attention to this work, and the apparent inactivity during the period of reorganization that followed his retirement led many to fear that the Commission would not be revived.

Happily this fear was groundless. After a period of necessary reorganization and adjustment, the Commission in 1943 launched a new program of activity and publication that assures it greater efficiency and usefulness than it has ever had before. The new secretary, Capt. Hemming, deserves the most hearty commendation for his leadership in this renaissance. Henceforth the Commission will issue three forms of publication: 1) *The Bulletin of Zoological Nomenclature*, 2) *Declarations of the International Commission on Zoological Nomenclature*, and

3) *Opinions of the International Commission on Zoological Nomenclature.* It will also reissue all *Opinions* published during Professor Stiles' incumbency with additional information on code. These are invaluable to taxonomists and have been long out of print.

The *Bulletin* is the official organ of the Commission and will be used to publish (a) proposals on zoological nomenclature as they are submitted to the Commission, (b) comments received from and correspondence by the Secretary with zoologists on proposals already published in the Bulletin and pending action by the Commission, and (c) "papers on nomenclatorial implications of developments in taxonomic theory and practice." This most welcome new device will insure that proposals submitted to the Commission will be promptly brought to the attention of all interested persons so that an opportunity will be available for participation in the discussion of its merits while action is pending. It will also give all zoologists a preview of matters that are before the Commission.

The *Declarations* embody advice from the Commission on matters of general practice in nomenclatorial procedure. Their nature will be suggested by the following titles from among the twelve thus far published:

Declaration 1. Code of ethics to be observed in the renaming of homonyms.

Declaration 3. On the importance of giving a clear indication of the date of issue of every zoological publication.

Declaration 5. On the grant to the International Commission on Zoological Nomenclature of plenary powers to suspend the rules in certain cases.

Declaration 9. On the desirability of universities including zoological nomenclature in their courses of general and systematic zoology.

Declaration 11. On the need for a clear indication in the description of new genera and species of the order and family involved.

The *Opinions*, as in the past, will determine the application or interpretation of the *Rules* of Nomenclature in controversial cases. Since transfer of the Secretariat to London, *Opinions* 134 to 156 and 182 to 186 have been published and *Opinions* 1–6, long out of print, have been republished with illuminating explanatory comments.

An urgent appeal has been made for a fund of £1,800 to support the work of the Commission. It is estimated that this will finance the publication of materials now in hand and that the sale of these to subscribers will provide for further publication, thus serving as a revolving fund to meet future needs. An invitation will shortly be issued to all members and fellows of the Paleontological Society to join in raising a sum of money to be contributed to this revolving fund.

A great increase in the number of subscribers to the publications of the International Commission is urgently needed, not so much for the sake of the Commission as for that of the zoological profession itself. Inquiries and personal experience have persuaded members of this committee that the use of the *Rules* and *Opinions* of the International Commission on Zoological Nomenclature are lamentably neglected in paleontological departments throughout American universities, many of which do not possess a full set of the *Opinions*. Every professional paleontologist should have on his desk a full set of the publications of the Commission for quick and frequent reference. They are an essential part of the equipment of any student of taxonomic paleontology and need to be consulted frequently even by those working in other branches of the science. Every graduate student majoring in paleontology should have instruction and practice in the use of the *Rules*. A complete set of the publications of the Commission should be kept in the departmental library where it is readily available.

During recent years strict application of the rules of priority has led to the replacement of many widely used generic names by others long since forgotten. In some instances this has clearly defeated the very purpose of the *Rules*, which is to insure *stability* of nomenclature, and some American paleontologists have felt inclined to rebel at such miscarriage of the intention of the rule of priority. The feeling became acute during the years of reduced activity of the Commission when it was impossible to get prompt action on a proposal to suspend the *Rules*. Those who have been disturbed by such

miscarriage will note with delight *Declaration 5*, which calls attention to the fact that the Commission is authorized to suspend the *Rules* as applied to any given case, where in its judgment their strict application would clearly result in greater confusion than uniformity. The present provisions for prompt publication of proposals brought before the Commission, and the promise of prompter attention to all proposals, should remove this basis of criticism. It should induce specialists to seek formal suspension of the *Rules* when it is obviously desirable, rather than illegally to ignore the *Rules* or to upset long established nomenclature by following them too blindly.

Secretary Francis Hemming may be addressed at the British Museum (Natural History), Cromwell Road, London, S.W. 7, but publications of the Commission are to be had by addressing the Publications Office of the Commission at 41 Queen's Gate, London, S.W. 7.

It will be a matter of interest to many readers that an American paleontologist, Dr. Harold E. Vokes, is now a member of the International Commission.

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REVIEWS

FOREIGN MAPS, by Everett C. Olson and Agnes Whitmarsh, xii+237 pp., 25 figs., 16 pls. Harper & Brothers, New York, 1944. $4.00.

Nearly every paleontologist has occasion at some time to consult foreign maps. He may be unfamiliar with the language of the country that they depict and with the symbols used on them. He may also need guidance in the search for and the selection of the most suitable map of the area in which he is interested. "Foreign Maps," by a vertebrate paleontologist and a librarian, discusses all of these problems.

Chapter I (pp. 1–17) describes maps of the United States. It lists the principal agencies that issue maps, the characteristics of the series, and the manner in which they are indexed. This description of maps of the United States in a book on foreign maps does not seem inappropriate, for American maps are foreign to everybody but Americans, but it is much more detailed than the discussions of maps of other countries, which are deferred to Chapter X.

Chapter II (pp. 18–26) states the problems that confront the user of foreign maps. These concern language, signs and symbols, grid systems, measurements and scales, and index systems. Chapter III (pp. 27–33) discusses the information to be found on the margins of maps, and Chapter IV (pp. 34–46) the kinds of indexes.

Chapter V (pp. 47–135) includes glossaries of the words used on maps. These glossaries are arranged by languages in alphabetical order, from Annamese to Turkish. This chapter should prove very helpful. The languages of the principal nations and territories of the world is the subject of Chapter VI (pp. 136–144).

Chapter VII (pp. 145–162), which is well illustrated, discusses the signs and symbols used on maps; Chapter VIII (pp. 163–169) treats of scales and measurements; and Chapter IX (pp. 170–194) discusses grid systems at considerable length.

The characteristics of the maps of the principal map-making agencies exclusive of those in the United States are described in Chapter X (pp. 194–222). This follows in the main the outline of Chapter I but is more condensed. The purpose of this chapter is to aid in the selection and use of maps for the study of areas outside of the United States. Catalogues and reports of these agencies are listed after a bibliography of general works (pp. 223–230).

As the preface points out, the arrangement of the chapters is intentionally illogical. It represents the supposedly normal approach of a person unfamiliar with foreign maps. This arrangement detracts from the value of the book for reference. Use as a reference book would have been made more easy had the topics been better segregated. For instance, the topic "grid systems" is listed in the table of contents under Chapters II, III, and IX, and it is discussed also in several other chapters.

C. WYTHE COOKE

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